Ontario

RESOURCE CONSERVATION

GUIDE TO Resource Conservation and Cost Savings Opportunities for Office Buildings

Ministry of the Environment

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Guide to Resource Conservation and Cost Savings Opportunities for ➲ Office Buildings

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in association with:
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Disclaimer

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Acknowledgement

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We wish to acknowledge the work and effort of the following organizations and private firms in providing valuable information, technical input and comments throughout the development of the Guide. We are grateful to the members of the Steering Committee who made themselves available throughout the project and who volunteered their time and expertise to ensure that this document would be a useful tool for commercial property managers:

- Edward Aldcroft, David Snelgrove, C.S.(Chuck) Stradling and Lynn Johnston, Building Owners and Managers Association, Toronto
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The Ministry of the Environment and the Building Owners and Managers Association encourage the distribution of this publication which we hope will support the continued efforts of property and facility managers in achieving a strong program of conservation and sustainable development. The Ministry and BOMA strongly support the concurrent promotion of resource conservation, pollution prevention and commercial competitiveness through measures that include savings in energy, water and other materials, as well as source waste reduction.

Ontario

BOMA TORONTO
Building Owners And Managers Association Of The Greater Toronto Area

Dear Reader:

The Ontario Ministry of the Environment and the Building Owners and Managers Association of the Greater Toronto Area are pleased to provide this copy of the ***"Guide to Resource Conservation and Cost Savings Opportunities for Office Buildings"***. The guide was prepared jointly by the ministry and the Building Owners and Managers Association of the Greater Toronto Area.

The guide identifies and promotes opportunities for conserving energy and water, as well as reducing waste, within office buildings. By taking advantage of these opportunities, operators can lower their costs, while at the same time conserving valuable resources and improving the comfort of their buildings.

Many people have an interest in further improving environmental performance, including owners, managers and employees, suppliers, engineering designers and consultants. By combining your own knowledge and skills with the information contained in this guide, we can help keep the Ontario office building sector competitive by becoming more efficient, by increasing tenant satisfaction, and by conserving valuable resources.

We hope this guide is useful to you and your facility. We would be grateful to receive any comments or questions you may have about this publication. You may contact the Ministry of the Environment at (416) 327-7721 or by fax at (416) 327-1261.

Daniel Cayen, Director
Industry Conservation Branch
Ministry of the Environment

C.S. (Chuck) Stradling, President
Building Owners and Managers
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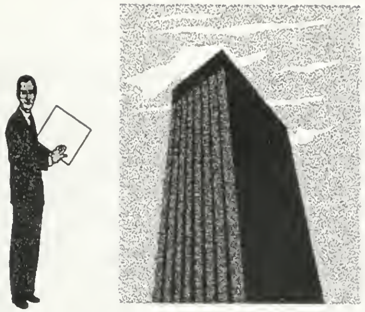


RESOURCE CONSERVATION AND COST SAVINGS OPPORTUNITIES FOR OFFICE BUILDINGS

INTRODUCTION

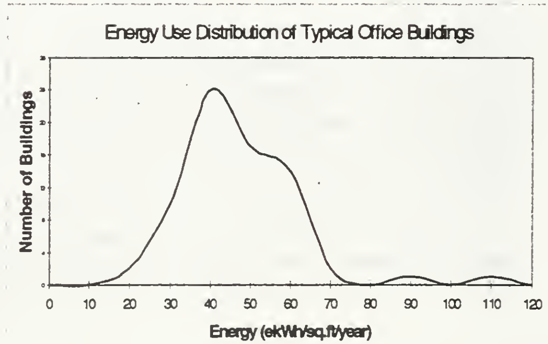
This guide has been designed to help office building owners, property managers, and operators find ways to save money on energy, water and waste management in your building. It can also help to reduce the total impact your building has on the environment. The guide is designed to lead you through the process of identifying, evaluating, implementing and monitoring initiatives in these three areas. We start by presenting an organized approach to building operations, and then move on to a detailed discussion of the steps to take to implement important measures to conserve resources and reduce waste.. The process we suggest has three Phases, entitled Audit - Implement - Monitor, *or* AIM. *Each Phase may have more than one step. Finally, we provide an overview of the current state of regulations and good practice on environmental issues, and close with some useful information on resource conservation and waste management regulations, and sources for information and training. More details about each subject, including several worked examples and worksheets for your use, are contained in the chapters at the back of this guide.*

SOME BENCHMARKS TO CONSIDER

Benchmarks are a reference or standard against which to measure the performance of your building. In this section, we provide some simple average benchmarks for typical office buildings in Ontario. Your building is unique in many respects, and ideal benchmarks for energy, water and waste would recognize those unique aspects. One of the steps we will describe will lead to the development of specific benchmarks for your building.

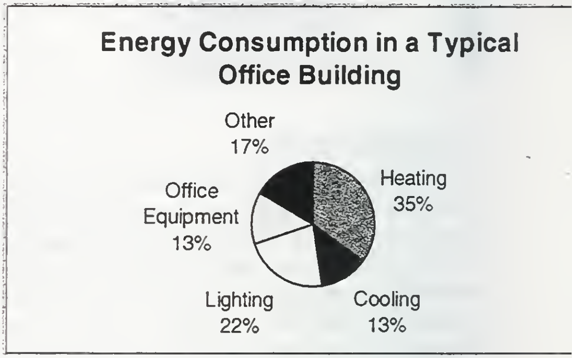
Energy

This graph shows the distribution of total energy use for a sample of office buildings in the Toronto area. The unit of measure is "equivalent kilowatt-hours of energy use per gross floor area per year (ekWh/ft²/yr)." It is simply the total metered energy consumption in ekWh (multiply cubic metres of gas by 10.248 to get ekWh) for one year divided by

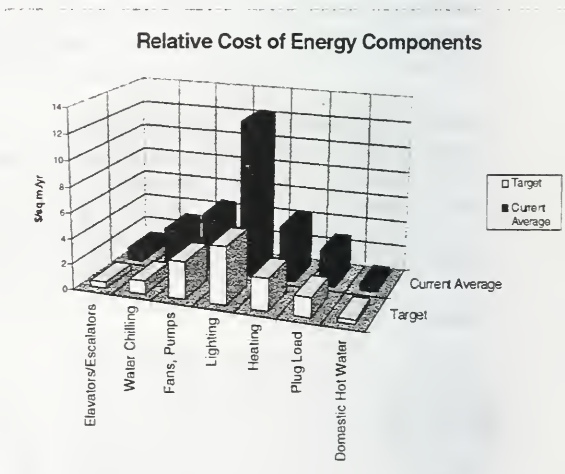


the gross floor area. While the average from the graph is about 40 ekWh/ft^2/yr, lower energy use can be readily achieved through a combination of energy measures, efficient operations, and tenant cooperation. An older energy efficient office building can operate at 25 ekWh/ft^2/yr, while an energy efficient new office building may be as low as 15 ekWh/ft^2/yr

This graph shows the proportionate energy consumption for a typical single purpose office building in southern Ontario for the four largest energy uses, Space Heating, Space Cooling, Lighting, and Office Equipment (sometimes called "plug load"). The graph represents a building using natural gas for heating and service hot water, and electricity for all other uses. These proportions will change for an all electric building, as the consumption of energy is less for heating and service (non-space heating) hot water. The proportionate cost *of the energy, however, is very different for the two cases.*

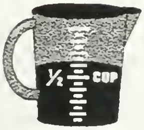


One key issue for a resource conservation program for your building will be to establish annual cost targets for the various energy uses. In this graph, we have provided a comparison of current annual costs for a number of end-uses for a typical medium-to-large office building. The second (and shorter) set of bars provides comparative achievable annual costs after modifying operations, implementing measures, and motivating tenants to conserve energy.

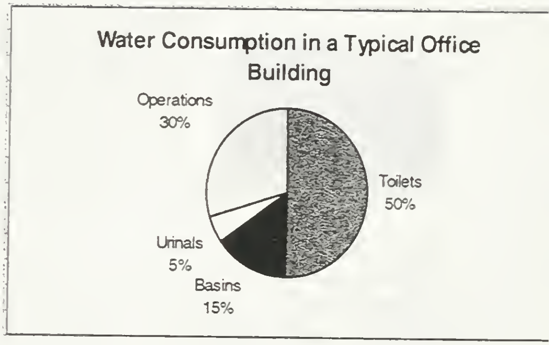


From this same graph, it is easy to see where most of the expenditure is made to keep the building well lit and comfortable. Lighting represents the largest cost for energy, and has the greatest potential for savings. Space heating and fans and pumps cost about the same and have similar savings potential. Plug load is mainly a tenant issue and requires their cooperation and participation in an office equipment energy cost reduction program. Service water heating and elevators are smaller uses, but have proportionately equal cost savings potential.

Water



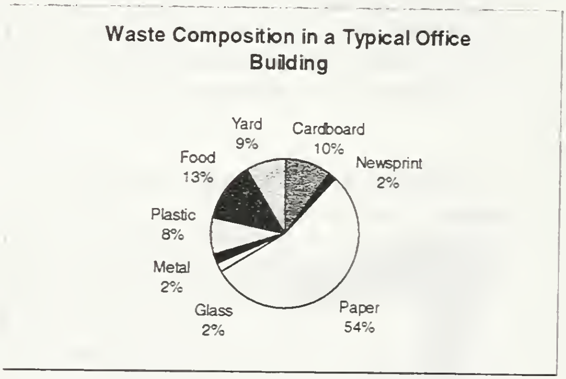
Office building water use falls in the range of 0.15 - 0.25 $m^3/ft^2/yr$. Principal uses are domestic, (cleaning, washroom facilities), and building operations (makeup water for cooling towers and boilers , once-through cooling, and irrigation). Water for toilets is the largest single use. For buildings having food service or some types of retail, water use will be higher.



Water conservation efforts are very visible to tenants and occupants when undertaken on domestic water end-uses. This demonstrates the concern of building management for the environment, and motivates building occupants to participate in all the resource and waste initiatives within the building.

Waste

The composition of the waste stream from a typical office building is shown in this graph. Paper comprises over 50% of the total, with the rest made up of food, yard waste, plastic, cardboard and miscellaneous products. The total waste stream from an office building ranges from 0.3 to 0.5 $kg/ft^2/yr$.



Waste management is an area which requires extensive cooperation between building managers and occupants. The amount and cost of waste haulage can often be reduced significantly through a program of waste management involving everyone in the buildings. We include a description of the steps required to assess the current waste stream and to implement a reduce, reuse, recycle program.

Chapter 1: BUILDING OPERATIONS AND MAINTENANCE

From an operations and maintenance perspective, the issue which receives first priority in your building must be the health, comfort and safety of the occupants. The next priority is to ensure the mechanical and electrical equipment and systems are always available to serve the needs of the occupants. Finally, the building systems must be operated and maintained to maximize the asset value of the building and to optimize the owner's return on investment.

Within the framework of these priorities, however, it is reasonable and practical to establish operational requirements which address resource conservation issues. Many of these are consistent with occupant and owner issues. A program to ensure the efficient use of energy and water can coexist with the satisfactory operation of the building. Managing waste makes good business sense and impresses tenants with your concern for the environment.

In Chapter 1, we have listed a number of ways to reduce energy and water use by making small changes in operations. It is always true that good building operations and maintenance can improve an inefficient building, but even the best equipped building will not perform efficiently unless operated properly.

Every occasion where a building component or piece of equipment requires replacement or renewal should also be viewed as an opportunity to improve the utilization of energy and water by considering the incremental cost of the more efficient alternative against its cost savings potential. This is discussed in detail in Chapter 3.

Chapter 2: THE AUDIT PHASE

The audit phase is designed to provide an answer to questions such as, "How much energy does my building use for space heating (or cooling, lighting, office equipment, etc.)." Or "How much water do my tenants use for sanitation." *This is a necessary step in determining the potential payback of conservation measures which might be considered for your building. In Chapter 2, we have included an extensive description and some worksheets and graphs to assist you in developing an overview of the energy and water requirements, and the makeup of the waste stream. The steps in this process are as follows.*

1. *Assemble the following information for at least one, and preferably 3 years:*
   - *electricity bills*
   - *fuel bills*
   - *water bills*
   - *waste haulage bills*

2. *Analyse utility consumption and costs to provide:*
   - *annual and monthly energy and water consumption*
   - *annual and monthly energy and water cost*
   - *annual and monthly waste haulage costs*
   - *annual energy consumption and cost breakdown for the base load*
   - *define energy for heating and cooling*

3. *Undertake specific detailed audits to define:*
   - *energy for lighting*
   - *water for domestic and operating end-uses*
   - *sources of waste*

4. *The final step in the process is to assemble and organize the information in a way that will allow you to draw pie charts for your building which will be similar to those presented in the Introduction of this guide. Regular tracking of this information will allow you to develop a benchmark for your building against which to measure progress as you implement changes and improvements in resource conservation and waste reduction.*

Finally, we should note that audits for larger buildings can become quite complex, based on the information required, and the number and complexity of the building systems. You may require the assistance of outside consultants to complete this phase.

Chapter 3: THE IMPLEMENTATION PHASE

This is the point where you can begin to focus on the resource use and waste generation areas which have the best potential to pay back their investment through cost reductions over a reasonable period of time. Other considerations will also play a part in this selection process.

The selection of measures to meet all of the resource conservation and waste management objectives requires a considerable amount of experience. We have attempted to put as much of this as possible in the descriptive sections of Chapter 3 to assist you in this process. Where the measure is complex and expensive, seeking professional assistance may be a wise decision.

SELECTING PROSPECTIVE MEASURES FOR YOUR BUILDING

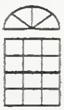
The selection of measures is dependent on a number of factors:

- *the resource consumption of the end use*
- *the cost of the measure*
- *the payback of the measure*
- *the size of your budget*
- *the practicality of the measure*

Many measures are large in scope and complex in nature. These require careful planning, and the use of outside consultants and contractors. Others may be as simple as changing the specifications for purchasing components, or gaining the participation of staff and occupants.

Lighting *- Lighting is the major electrical energy end use in most office buildings. Lighting technologies have advanced dramatically in the past 5 years for all types of lighting (fluorescent, incandescent, high intensity discharge) and many of these can be used both retrofit and new applications.*

Mechanical Systems *- Modern heating and cooling equipment operates at higher efficiencies than many older types. In some cases, distribution system efficiencies can also be improved. Auxiliaries such as fans and pumps which operate at part load can be fitted with variable speed drives.*



Building Envelope *- Windows are the largest source of heat loss and external heat gain in the building. Some types of window film can reduce both heating and cooling loads. Insulation added to walls and roof can reduce heat loss in these components. Air sealing of doors, cracks and other openings can be very cost effective.*

Water Conservation *- Implementing a program of adding water conserving automatically controlled aerating faucets, low flow toilets and urinals, and low flow shower heads, whenever replacement is necessary, supported by a regular program of repairing and maintaining leaking fixtures, will both save money and impress building occupants with your commitment to the conservation ethic.*

Waste Management *- The three R's of waste management, reduce, reuse, and recycle, can be implemented throughout all aspects of the building operation. These include construction, renovation and operation. Look for information from your local municipality, and coordinate your efforts with the building occupants, waste hauler, and your suppliers.*

Chapter 4: THE MONITORING PHASE

This is the phase where you will track the success of your program, and establish accurate benchmarks for your building. Monitoring is undertaken to:

- *measure the results of conservation efforts*
- *identify equipment malfunctions*
- *identify consumption pattems*
- *maintain staff and occupant commitment*
- *help plan further conservation/reduction measures*

Monitoring is a very necessary step to the AIM process. It can be achieved by setting up a simple recording and reporting structure in your organization. Most of the information is already available, and only needs to be accumulated and organized. The sources are:

***Electricity, Gas and Water** - the utilities who provide these resources to your building also provide metering services. Use this information in your monitoring program by recording the meter readings off their bills, and summarized. Watch the consumption pattems for the beneficial effects of your conservation program, and for changes which may be due to operation difficulties, occupant changes, or even errors in utility billings.*

One key issue is the rate structure offered by the electricity, gas and water utilities. We have provided an extensive discussion on rates, their impact on savings calculations, and ways to minimize utility bills by ensuring your building takes advantage of the rate characteristics.

***Waste Management** - Tracking this item is mainly done by summarizing waste haulage costs, and by monitoring waste separation at site. Facilities for separation should be regularly checked and problems noted for correction. Where there is a cafeteria or other food service operation in the building, this should receive careful monitoring to ensure waste costs are kept to a minimum.*

Chapter 5: ENVIRONMENTAL ISSUES

This chapter discusses the four key environmental issues for office buildings: asbestos, CFCs, PCBs, and fluorescent lamp disposal. We start with an overview of the historical use and application, review current federal and provincial regulations, and discuss recommendations for planning and implementing a program to remove them from your building over time. Some of this removal will result from the implementation of a resource conservation program.

Chapter 6: USEFUL INFORMATION

There are many regulations which affect the way you operate your building. We have assembled a description of the federal and provincial regulations which relate to energy and water conservation, waste management, and disposal of hazardous waste.

Many of the minimum standards for energy and water use are embodied in the Ontario Building Code and directly affect only new buildings. There are also product regulations which set minimum performance levels for equipment and components which can be sold in Canada and Ontario. These are contained in federal and provincial Energy Efficiency Acts, and cover products ranging from boilers and motors through to plumbing fixtures and light bulbs. These will have a direct impact when it is necessary to purchase replacements components for your building.

Current minimum performance standards from new building codes and regulations can be a worthwhile reference when undertaking any upgrades to your building, to establish design criteria for building envelope components, heating and cooling equipment replacement, or plumbing fixtures. Requirements for waste management are often set at the municipal level and relate to the collection and sorting of waste. While we have not included any municipal regulations, due to their variety and localized nature, they are readily available from the local authorities.

We have assembled a list of sources of information on energy, water and waste in office buildings. Almost all of these can be accessed on the Internet, or by mail.

CONCLUSION

We have described a process for implementing a program of resource conservation and cost savings for your office building. The keys to the success of that program lie in its execution. These are:

- *Make a plan for your program. Circulate the plan for comments and get buy-in from all stakeholders. Then follow the plan.*
- *Keep meticulous records and look for changes in use or cost. These may be caused by tenants, building operators, or external influences, but they need to be corrected.*
- *Don't stop after the first success (or failure). Keep moving forward. There are lots of opportunities available, and these will increase as energy, water and waste costs rise and technologies mature.*
- *Keep everyone involved through regular communication and feedback. Use lots of graphics to make the point clearly and easily. Their interest will wane unless you keep them informed of new initiatives and the ongoing success of your program.*

1. Building Operations and Maintenance

Preliminary Considerations

Before money is spent making expensive changes to a building or building system, it is worthwhile to examine the operation of the building to determine what changes can be made to reduce energy use and conserve water. A few no-cost or low-cost changes to the building operation can often achieve a significant reduction in resource use.

- Common types of equipment, such as fans and pumps, heating equipment, chillers, cooling towers, water heaters, air conditioners, heating cables, elevators, escalators and conveyors, should be questioned as follows:
    - is it necessary?
    - how is it started?
    - can it be started later?
    - how is it stopped?
    - can it be stopped earlier?
    - can it be run more slowly?
- Determine how all energy-using equipment is controlled, for example, by manual switch, time clock, thermostat, or other equipment.
- Check the operation of these controls to ensure that the equipment runs no longer than is necessary to perform its required function.
- Check all plumbing, heating and chilled water fixtures for excessive water use including leaks, flush valves not closing, boiler relief valves leaking, or excessive cooling tower water blowoff.

Building Temperatures and Operating Schedules

The thermal factors which result in providing comfortable conditions for building occupants, have been studied extensively by ASHRAE and others. Those which can be controlled by the building include temperature and relative humidity, and air velocity or draft. Other factors which can have an affect include amount of clothing, nonuniform thermal radiation and localized temperature variation. It has been shown that occupant age and sex have a minor impact on requirements for comfort conditions.

ASHRAE Standard 55-1992, *Thermal Environmental Conditions for Human Occupancy*, provides the following table for winter and summer thermal conditions:

Optimum and Acceptable Ranges of Operative Temperature for People during Light, Primarily Sedentary Activity (≤ 1.2 met) at 50% Relative Humidity and Mean Air Speed ≤0.15 m/s (30 fpm)[1]

Season	Description of typical clothing	I_α (clothing factor)	Optimum operative temperature	Operative temperature range (90% satisfaction criterion)
Winter	Heavy slacks, long-sleeve shirt and sweater	0.9	22°C 71°F	20-23.5°C 68-75°F
Summer	light slacks and short-sleeve shirt	0.5	24.5°C 76°F	23-26°C 73-79°F
	minimal	0.05	27°C 81°F	26-29°C 79-84°F

[1]Other than clothing, there are no adjustments for season or sex to the temperatures. For infants, certain elderly people, and individuals who are physically disabled, the lower limits should be avoided.

The winter minimum temperature in the Operative temperature range should be raised by 1 °C if the relative humidity is maintained at 30%. The summer maximum temperature should be lowered by 1 °C if the relative humidity is maintained at 60%.

For setback and setup of space temperature and control of other energy uses during unoccupied periods, the following factors should be considered:

- Heat the building to a maximum of 16°C (61F) when unoccupied. Heating and cooling setpoints must be independent so that the air conditioning doesn't start up when the heat is on.
- Start morning temperature pickup with outside air dampers closed so that the building is at 20°C (68F) when occupants arrive. Complete the warmup during the first hour of occupancy. Similarly, set back the temperature for the last hour of occupancy.
- Cool the building to no lower than 24°C (75F) when occupied. Don't use mechanical cooling when it is unoccupied except if necessary for morning precooling.
- Start morning precooling so that the building is 26°C (78F) when the first occupants arrive. Complete the cool-down during the first hour of occupancy. When practical, cool the building overnight using cool outside air.
- Schedule cleaning and maintenance to overlap regular hours. After hours, cleaning should be done by area, using only the necessary lights in the area being cleaned. Temperature setback should be used during after-hours cleaning.
- Concentrate off-hour occupancy in a single area if possible. If systems have adequate flexibility, only this area need be lighted and heated or cooled.
- Set the domestic hot water temperature with due regard for all health, safety and equipment factors. For most office building, a setting of 50°C (122F) should be adequate. If there is any doubt as to the appropriate operating temperature for your water heater, you should consult your local medical health officer, plumbing inspection authority and supplier of equipment such as water heaters and dishwashers.
- Shut down domestic hot water circulating pumps during unoccupied hours.

Air Handling and Ventilation Systems

Reduce the amount of outside air brought into the building to the minimum acceptable level during occupied hours in the heating season. Required ventilation rates depend on building use, occupancy, and type of ventilation system. Useful recommendations for minimum ventilation rates for various buildings are contained in the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*. Other authorities include the Workers' Compensation Board, Ministry of Labour as well as local building officials.

- If the ventilation system has the capability of introducing large volumes of outdoor air, it can be used for cooling during mild weather.
- Outside air can also be used at night and in the early morning to precool the building prior to occupancy.
- During the cooling season it may be practical to precool down to 21°C (70F) using outside air. However, the outdoor air quantities must be reduced to minimum when not required for cooling.
- Shut down the air handling system when the building is unoccupied – nights, weekends and holidays. During these periods, if operation of the air handling system is necessary for heating, it can be run on a demand basis.
- Fans come on only when the thermostat calls for heat, rather than operating continuously.
- Outside air dampers should be closed during these periods so that no ventilation is provided when fans come on to meet a heating demand.

Building Envelope

Building envelope maintenance is concerned with minimizing air and moisture leakage and with maintaining the thermal quality of the building.

- Seal all unused openings and stacks, and any joints and cracks in the building construction.
- Inspect and repair weatherstripping and seals around exterior doors and windows. Replace broken glazing and repair window putty.
- Check doors to ensure that the gap between the door and doorway is as small as possible. Adjust door closers and ensure that doors are not being propped open. In order to encourage the closing of doors in cold weather, consider installing limit switches to shut off heaters when doors are open.
- Check seals on shipping and receiving doors and repair if necessary.
- Inspect roofing (possibly by infrared scan) to determine if moisture is penetrating the membrane and wetting the insulation, thus negating its effectiveness.

Lighting

There are a variety of reasons to practice *group relamping* rather than *spot relamping*, in which lamps are only replaced when they burn out. Most of these reasons apply to fluorescent and HID lamps rather than incandescents, which have much shorter lifetimes and less lumen depreciation (reduction in light output over time).

Economic comparisons typically show that group relamping has higher lamp costs but lower labour costs than spot relamping.

- On a per-lamp basis, group relamping requires much less labour than spot relamping. To replace a spot burn-out can take a worker as much as a half-hour to fetch the new lamp, set up, and install it. Having all the materials on hand and moving systematically from one luminaire to the next, reduces the required time to about three minutes per lamp,[8] and reduces disruption of normal activities, since the group relamping is normally done outside working hours.
- Group relamping is an easy task to schedule and delegate to outside contractors, who have special equipment and training. This reduces administrative overhead by enabling a smaller in-house maintenance staff (although some spot relampings will still be required).
- Group relamping provides brighter and more uniform lighting, because it gets rid of lamps before they are at the end of their lumen depreciation curve.
- Group relamping offers increased control over the replacement lamps, reducing the probability of mixing incompatible lamps - such as those with different colour temperatures.
- Other maintenance activities can be combined with group relampings, such as ballast and reflector inspection and lens cleaning. Group relamping also provides an opportunity for retrofitting reflectors, lamps, ballasts, or lenses as necessary.

Group relamping is normally done at about 60 to 80 percent of rated lamp life, depending on variables such as the ratio of spot to group relamping labour cost, requirements for fixture cleaning, and the cost and mortality curves of the lamps. Group relamping can be done by a user's own maintenance staff or by a specialize lighting-maintenance firm or other contractor. Contractors often have specialized equipment which greatly reduces the cost and increases the effectiveness of lighting maintenance. This includes not only access equipment, such as telescoping scaffolding, but also ultrasonic lens-and louver-cleaners.

Economic comparisons typically show that group relamping has higher lamp costs but lower labour costs than spot relamping. One such comparison has shown a 31 percent overall savings from group relamping. This result is dependent on the difference in labour costs between group and spot relamping. For example, if the group relamping cost of $1.50 per lamp jumps to $3.50, the balance tips in favour of spot relamping. Remember, however, the non-economic benefits of group relamping discussed above before deciding between the two methods.

In real buildings, lamps that burn out may not be replaced for weeks, providing a windfall energy savings that can be included in analyses for greater accuracy. In the Table 1-1 example, this savings would amount to a $212 credit for the spot relamping program, assuming two weeks of non-burn time, 30 watts of avoided power per lamp, and 10¢ per kWh total energy costs. Longer delays could conceivably shift the economics in favour of spot relamping, but slow response is hardly a useful energy savings (or maintenance) practice. One could also achieve the same energy savings in group-relamped buildings by randomly removing some lamps.

Economics of group vs spot relamping for 1,000 3-lamp T8 lensed troffers
Group relamping has higher lamp costs but much lower labour costs, in this case providing a 31% overall savings. Group relamping also provides additional benefits in lighting quality and easier facility management.

	Relamp cycle (hours)	Average relamps per year	Average material cost per year	Average labour cost per year	Total average cost per year
Spot relamping on burnout[a]	20,000	525	$1,391	$3,150	$4,541
Group relamping at 70% of rated life[b]	14,000	750	$1,988	$1,125	$3,113
Difference		225	$597	-$2,025	-$1,428 31% savings

Notes:
[a] Assumes labour costs of $6.00/lamp for relamping and cleaning, material cost of $2.65/lamp, and 3,500 hours/yr operation.
[b] Assumes labour costs of $1.50/lamp for relamping and cleaning, same material costs and operating hours as for spot relamping.
Source: EPA

Water

A scheduled program of leak detection and repair can provide considerable savings in water and energy costs for a small increase in maintenance effort, particularly at larger and older office buildings and commercial establishments. All tank toilets should be "dye-tested" to check for leaks. This simply involves placing a small tablet of dye in the tank, waiting 15 minutes, and checking the bowl to see if any water from the tank, coloured by the dye, has leaked into the bowl. Dye tablets are inexpensive. Alternatively, several drops of food colouring can be added to the tank instead of the dye.

Operating and Maintenance Instructions

Ensure that written operating and maintenance instructions are available for all building systems.

- a brief description of each system, its controls and functions
- a description of the operation of the systems in winter (heating only), summer (cooling only) and spring and fall seasons for both occupied and unoccupied hours
- a troubleshooting guide for operators on how to handle minor problems – what adjustments can be made without upsetting the whole system or when to call in the contractor
- required cleaning and relamping schedules for lighting systems
- cleaning, lubricating and maintenance schedules for mechanical equipment
- a floor plan of operating areas for light switching and HVAC operation.

2. The Audit Phase

2.1 The Energy Audit

The purpose of an energy audit is to determine the total energy consumed by a building over a defined period of time (usually one year) by energy/fuel type, and where this energy is used within the building. Utility bills provide the total amount of energy the building is using. This can be viewed as the whole "energy pie." The energy audit process then provides a method for determining how the "pie" is sliced; that is, how much of the total energy is being used in the building for end-uses including space heating, space cooling, lighting, plug load, etc. This process is called disaggregation. With this breakdown into energy end-uses, attention can be focused on those end-uses having the greatest conservation potential, and a selection of energy saving measures can be undertaken.

A Level I energy audit will determine annual energy consumption for the following end-uses:

- space heating
- space cooling
- lighting
- all other loads, including service water heating, plug load, outdoor lighting, refrigeration, etc.

Methods for both all-electric and gas-electric office buildings are included.

A Level II energy audit provides a more accurate evaluation of the major energy end-uses. A methodology for further disaggregation of the other load into its component parts is provided in this section

In addition to the description, sample audits for both an all-electric and a gas-electric building are included.

Level I – Energy for Heating, Cooling, Lighting and Others

This methodology, along with a worked example, is provided for performing a simple energy audit on an all-electric building and a gas-electric building (where natural gas is used for space and service water heating). It is important to note that, whether the building actually being assessed is similar to that used in the examples or not, the methodology is exactly the same. All audits begin with analysis of the utility bills and proceed from that point to disaggregate the energy into its end-uses.

Some larger commercial all-electric buildings require space cooling year-round to meet internal loads, creating a total electrical load which is essentially flat, even in the shoulder months. For these buildings, all loads appear to be non-weather sensitive and defining a base load is not possible with this technique. Also, the technique described in this section is not directly applicable to a building using direct-fired natural gas absorption cooling or indirect-fired absorption cooling from steam boilers in the building, or for buildings using any type of district energy for heating or cooling.

All-Electric Building

Methodology

Step 1: Analysis of Utility Bills

The first step is to define the total amount of energy, and the cost of that energy, which the building is currently using, by energy type.

1. Record monthly utility billing data for a one year period.

2. Place this data on a graph .

Note: *The most recent year usually best represents current operating conditions. If, however, there have been unusual conditions in the building during that year, a different year should be selected. The year can be any 12-month period, but for clarity, the example follows a calendar year.*

A form which can be used to tabulate billing data is provided in Figure 2-1. Information from this form can be used to create a graph of the total energy use and cost over the twelve month period, providing a visual sense of the energy use and energy cost patterns of the building. The graphs in Figure 2-2 can be used to manually plot utility billing consumption and cost data. Note that consumption is plotted using the left vertical axis, and cost using the right vertical axis. This data can also be entered into a computer with spreadsheet software and the graph plotted by the same program.

Sample utility data and graphs have been provided in Example 1 for an all-electric building.

Step 2: *Determining Energy for the Base Load*

The electric utility bill for an all-electric building includes energy use for all heating, cooling, lighting, plug load, pumps, fans, etc., combined as a total usage per month. Some loads, namely space heating and space cooling, are Weather Sensitive (WS) loads. All other loads do not vary significantly with weather, and are collectively referred to as the non-weather sensitive or Base load. The first and easiest load to identify energy consumption and cost is the Base load.

For all-electric buildings which heat only in the heating season and cool only in the cooling season, the Base load would comprise all non-heating and non-cooling loads, such as service hot water, lighting, plug load, etc. These loads remain relatively constant throughout the year.

- Look at energy use in the shoulder months, typically April, May, September and October, depending on geographic location.

Note: *Shoulder months are months in which the space heating and space cooling loads are at their minimums. During these months, the outside temperature will be at or near the balance point temperature of the building (the temperature at which no heating or cooling is required). With no significant heating or cooling loads, the energy use in these periods is consumed almost entirely by the Base or non-weather sensitive load.*

Example 1 illustrates the determination of the monthly energy used by the base load from utility bills for a building of this type. From the graph of monthly utility bills, a horizontal line can be drawn at the minimum energy consumption. All energy below the line is used by the Base load, and all energy above the line is for the WS load.

Step 3: *Estimating Energy for Heating and Cooling Loads*

- Determine the energy for space heating by adding the energy consumption for all heating months (October through March), less the base load for these months.
- Determine the energy for space cooling by adding the energy consumption for all cooling months (April through September), less the base load for these months.

Step 4: Disaggregation of the Base Load

In this step the Base load will be disaggregated into two parts: the lighting load and all other loads. Lighting is usually the largest electrical load in an office building.

In order to establish the lighting load, a lighting audit must be conducted.

4.1: The Lighting Audit

1. Walk through the building and record the types and ratings of lamps and fixtures. The building may have a variety of different lamp types and fixture designs, but there will be considerable replication. *A list of lamp and fixture combinations, and the total load for each one, is provided in Figure 2-3 and can assist in categorizing those types installed in the building.*

2. Count the number of each type of fixture in the building. *A format for recording the appropriate information is provided in Figure 2-4.*

3. Insert the appropriate number of watts per fixture or lamp for each type from the information in Figure 2-3.

4. Provide an estimate of the annual operating hours for each category. Base this on the best estimate available, taking into account hours of use per occupied day, weekend and statutory holidays, and management of lights by cleaners and others outside of normal occupied hours.

5. Multiply the number of fixtures of each type, load per fixture (watts) and hours of use to determine the annual energy consumption in kWh. The total energy for all lamps and fixtures in the building is the lighting energy.

4.2: Other Electrical Load

- Determine energy for the remaining portion of the Base load by deducting the lighting energy from the total Base load. This energy will be used for such things as service hot water, lights, HVAC auxiliaries (such as fans and pumps), plug load, etc.

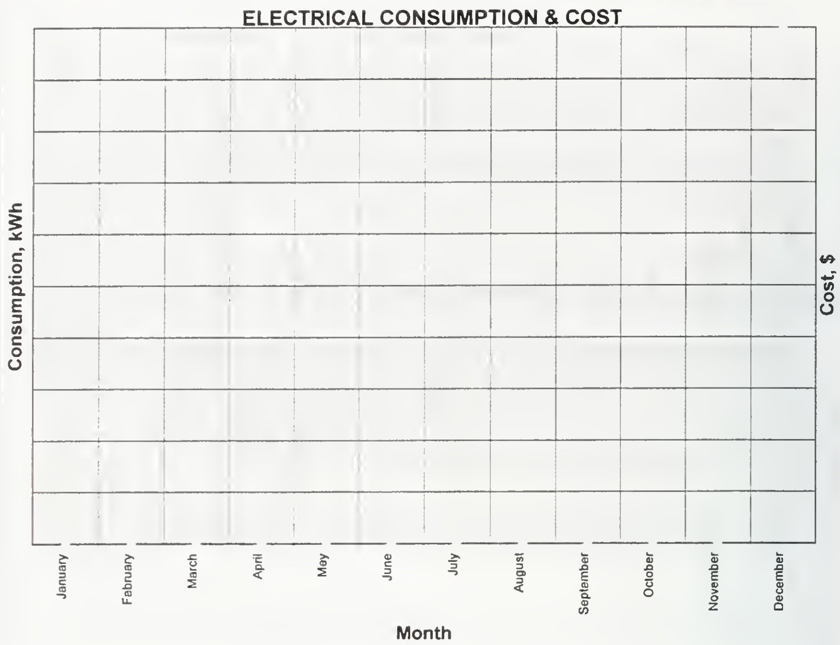
Step 5: Summary of Energy End-use

- Summarize the energy for each end-use in the table in Figure 2-5. A pie chart can be developed from this data for a graphical presentation.

FIGURE 2-1: UTILITY BILLING DATA SUMMARY

MONTH	ELECTRICITY			GAS		WATER	
	Consumption, kWh	Demand, kW	Cost, $	Consumption, m^3	Cost, $	Consumption, m^3	Cost, $
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							
Total							

Figure 2-2


ELECTRICAL CONSUMPTION & COST
Consumption, kWh
Cost, $
January
February
March
April
May
June
July
August
September
October
November
December
Month

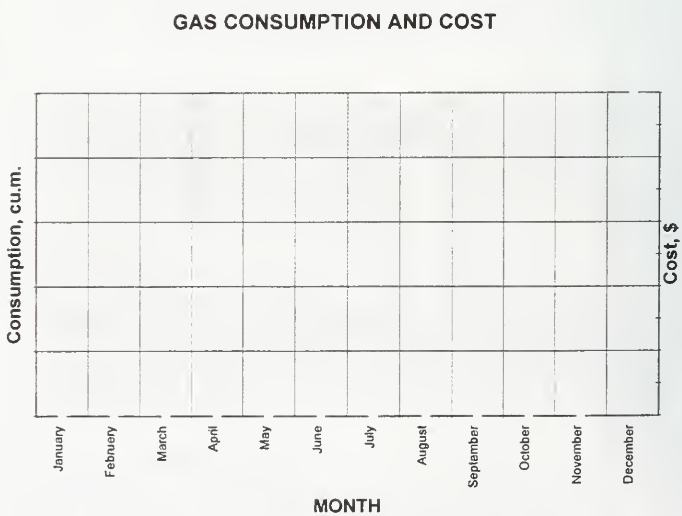

GAS CONSUMPTION AND COST
Consumption, cu.m.
Cost, $
January
Febnuery
March
April
May
June
July
August
September
October
November
December
MONTH

Figure 2-3: LAMP/FIXTURE ENERGY CONSUMPTION CHART

LAMP TYPE	LAMP TYPE	WATTS / LAMP	# LAMPS/ FIXTURE	BALLAST TYPE	WATTS / BALLAST	WATTS / FIXTURE
T-12 Fluorescent	F-40	40	2	magnetic	13	**93**
	F-40	40	4	magnetic	13	**186**
	F-40	40	6	magnetic	13	**279**
	F-40	40	8	magnetic	13	**372**
	F-34	34	2	magnetic	13	**81**
	F-34	34	4	magnetic	13	**162**
	F-34	34	6	magnetic	13	**243**
	F-34	34	8	magnetic	13	**324**
	F-40	40	2	es magnetic	5	**85**
	F-40	40	4	es magnetic	5	**170**
	F-34	34	2	es magnetic	5	**73**
	F-34	34	4	es magnetic	5	**146**
	F-34	34	1	magnetic	13	**47**
	F-20	20	1	magnetic	13	**33**
	F-20	20	2	magnetic	13	**53**
	F-30	30	1	magnetic	13	**43**
	F-30	30	2	magnetic	13	**73**
	F-25	25	2	magnetic	13	**63**
	F-25	25	1	magnetic	13	**38**
T-8 Fluorescent	F-32	32	1	electronic	0	**32**
	F-32	32	2	electronic	-6	**58**
	F-32	32	3	electronic	-6	**90**
	F-32	32	4	electronic	-12	**116**
	F-25	25	1	electronic	0	**25**
	F-25	25	2	electronic	-6	**44**
	F-17	17	1	electronic	0	**17**
	F-17	17	2	electronic	-6	**28**
	F-32	32	1	magnetic	8	**40**
	F-32	32	2	magnetic	8	**72**
	F-32	32	3	magnetic	8	**112**
	F-32	32	4	magnetic	8	**144**
	F-25	25	1	magnetic	8	**33**
	F-25	25	2	magnetic	8	**58**
	F-17	17	1	magnetic	8	**25**
	F-17	17	2	magnetic	8	**42**

Compact Fluorescent	Watts / lamp = Wattage given on bulb plus 20% to account for ballast
Metal Halide	Watts / lamp = Wattage given on bulb plus 15% to account for ballast
Mercury Vapour	Watts / lamp = Wattage given on bulb plus 15% to account for ballast
Incandescent (includes pot lights)	Watts / lamp = Wattage given on bulb (no ballast)

Figure 2-4: LIGHTING AUDIT FORM

ROOM / AREA	FLUORESCENTS					INCANDESCENTS & COMPACT FLUORESCENTS					TOTAL DEMAND, W	TOTAL CONSUMPTION, kWh
	WATTS / FIXTURE	# FIXTURES	WATTS	HOURS OF USE/YEAR	CONSUMPT-ION, kWh	WATTS / LAMP	NO. OF LAMPS	WATTS	HOURS OF USE/YEAR	CONSUMPT-ION, kWh		
Record room or area being audited	from Lamp Chart	count all fixtures of this type	= (watts/fixture) x (# fixtures)	= hours/day x days/week x weeks/year	= Watts/1000 (1000W = 1 kW) x Hours of use/year	read from lamp	count all lamps of this type	= (watts/lamp) x (No. of lamps)	= hours/day x days/week x weeks/year	= Watts/1000 (1000W = 1 kW) x Hours of use/year	= Fluorescent Wattage + Incandescent Wattage	= Fluorescent kWh + Incandescent kWh
EXAMPLE:												
Room 102	93	50	4,650	4,380	20,367	60	20	1,200	4,380	5,256	5,850	25,623
	33	10	330	4,380	1,445						330	1,445
Reception Area	33	4	132	6760	1,156	100	20	2,000	8,760	17,520	2,132	16,676
TOTAL												

Figure 2-5: ENERGY END-USE SUMMARY

METER TYPE: WS ELECTRIC METER

LOAD	kWh
TOTAL LOAD	= total kWh from utility billing data for 1 year
HEATING LOAD	= total use during heating months - (base load/month x no. of heating months)
COOLING LOAD	= total use during cooling months - (base load/month x no. of cooling months)
LIGHTING LOAD	= total kWh from lighting audit
"OTHER" LOAD	= total use kWh - heating load - cooling load - lighting load

METER TYPE: WS ELECTRIC METER

LOAD	kWh
TOTAL LOAD	
HEATING LOAD	
COOLING LOAD	
LIGHTING LOAD	
"OTHER" LOAD	

Example 1: Level I Audit of an All-Electric Building

The building used for this example is a medium size office building with eight floors, no parking garage and has no retail, food service or other occupancy type.

Step 1: Analysis of Utility Bills

Figure 2-6 shows the tabulation of the electrical energy billing data (use, demand, cost) and the same data has been assembled into a graph.

Step 2: Determination of the Base Load

This building heats only in the winter and cools only in the summer. Although consumption is high both in the winter and in the summer, the data shows a drop in the shoulder months, indicating periods where minimal heating or cooling is taking place. This can also be seen on the graph created in Step 1.

- To best estimate the monthly energy consumed by the base load, take an average of the shoulder month consumption.

April, May and September represent the shoulder months in this case, as all have relatively low usage.

Base Load is the average consumption in shoulder months (kWh)

Base Load = Total consumption for April, May, and September divided by 3

$$\frac{621{,}337}{3}\ kWh = 207{,}112\ kWh$$

Step 3: Estimating Heating and Cooling Loads from Utility Bills

Total Heating Energy

Total Consumption (October–March) – Base Load Consumption (October–March)

$$\begin{aligned} Total\ Heating\ Energy &= 2{,}064{,}728\ kWh - (207{,}116 \times 6) \\ &= 822{,}056\ kWh \end{aligned}$$

$$\textit{Total Cooling Energy}$$

$$\textit{Total Consumption (April–September)} - \textit{Base Load Consumption (April–September)}$$

$$\begin{aligned}\textit{Total Cooling Energy} &= 1{,}536{,}584\ kWh - (207{,}116 \times 6)\\ &= 293{,}912\ kWh\end{aligned}$$

$$\begin{aligned}\textit{Base Load Consumption} &= 207{,}112 \times 12\\ &= 2{,}485{,}364\ kWh\end{aligned}$$

Step 4: Disaggregation of the NWS Electrical Load

4.1: The Lighting Audit

The completed lighting audit for this building is presented in Figure 2-7. Figure 2-3 was used to determine the watts per fixture for each fixture type encountered.

The total lighting load of the building is 1,084,215 kWh

The "other" load is the remaining base load

$$2{,}485{,}364\ kWh - 1{,}084{,}215\ kWh = 1{,}401{,}149\ kWh$$

Step 5: Summarizing Energy End-use

A summary of the energy end-use breakdown is provided in Figure 2-6..

Figure 2-6

EXAMPLE 1: UTILITY BILLING DATA AND ENERGY END-USE BREAKDOWN (ALL-ELECTRIC BUILDING)

UTILITY BILLING SUMMARY			
MONTH	ELECTRICITY		
	Consumption kWh	Demand kW	Cost $
January	401,770	68.8	$30,133
February	364,676	62.4	$27,351
March	320,158	54.8	$24,012
April	212,339	36.4	$15,925
May	190,000	32.5	$14,250
June	261,112	44.7	$19,583
July	321,568	55.1	$24,118
August	332,567	56.9	$24,943
September	218,998	37.5	$16,425
October	277,887	47.6	$20,842
November	308,668	52.9	$23,150
December	391,589	67.1	$29,369
Total	**3,601,332**	**616.7**	**$270,100**

ENERGY END-USE SUMMARY	
LOAD	kWh
TOTAL LOAD	3,601,332
HEATING LOAD	822,056
COOLING LOAD	293,912
LIGHTING LOAD	1,084,215
"OTHER" LOAD	1,401,149

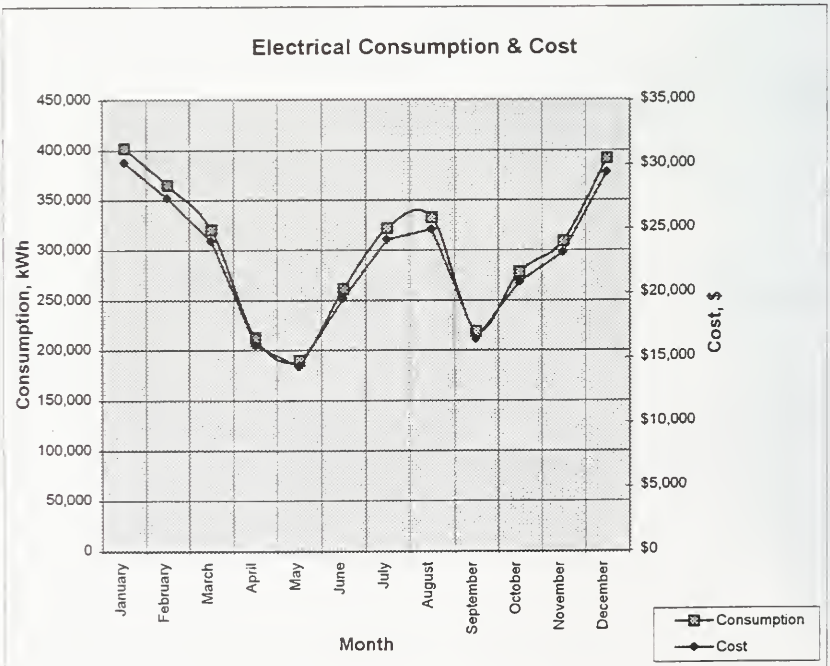


Figure 2-7: LIGHTING AUDIT FOR EXAMPLE 1

ROOM / AREA	FLUORESCENTS					INCANDESCENTS & COMPACT FLUORESCENTS					TOTAL DEMAND: WATTS	TOTAL USE: KILOWATT-HOURS (kWh)
	WATTS / FIXTURE	# FIXTURES	WATTS	HOURS OF USE/YEAR	USE: kWh	WATTS / LAMP	#LAMPS	WATTS	HOURS OF USE/YEAR	USE: kWh		
8th Floor offices	93	164	15,252	8760	133,608	100	9	900	4,380	3,942	16,152	137,550
8th Fl. storage & electrical	93	2	186	8760	1,629	100	3	300	8,760	2,628	486	4,257
8th Floor washrooms	43	2	86	8760	753						86	753
7th Floor offices	93	164	15,252	8760	133,608	100	33	3,300	4,380	14,454	18,552	148,062
	43	50	2,150	8761	18,838						2,150	18,838
7th Fl. storage & electrical	93	2	186	8760	1,629	100	3	300	8,760	2,628	486	4,257
7th Floor washrooms	43	2	86	8760	753						86	753
6th Floor offices	93	100	9,300	8760	81,468	100	28	2,800	4,380	12,264	12,100	93,732
	53	100	5,300	8761	46,433						5,300	46,433
6th Fl. storage & electrical	93	2	186	8760	1,629	100	3	300	8,760	2,628	486	4,257
6th Floor washrooms	43	2	86	8760	753						86	753
5th Floor offices	85	164	13,940	8760	122,114	100	19	1,900	4,380	8,322	15,840	130,436
5th Fl. storage & electrical	93	2	186	8760	1,629	100	3	300	8,760	2,628	486	4,257
5th Floor washrooms	43	2	86	8760	753						86	753
4th Floor offices	93	164	15,252	8760	133,608	100	18	1,800	4,380	7,884	17,052	141,492
						75	8	600	4,380	2,628	600	2,628
4th Fl. storage & electrical	93	2	186	8760	1,629	100	3	300	8,760	2,628	486	4,257
4th Floor washrooms	43	2	86	8760	753						86	753
3rd Floor offices	85	164	13,940	8760	122,114	100	16	1,600	4,380	7,008	15,540	129,122
3rd Fl. storage & electrical	93	2	186	8760	1,629	100	3	300	8,760	2,628	486	4,257
3rd Floor washrooms	43	2	86	8760	753						86	753
2nd Floor offices	93	164	15,252	8760	133,608	100	10	1,000	4,380	4,380	16,252	137,988
2nd Fl. storage & electrical	93	2	186	8760	1,629	100	3	300	8,760	2,628	486	4,257
2nd Floor washrooms	43	2	86	8760	753						86	753
Lobby	73	6	438	8760	3,837	150	33	4,950	8,760	43,362	5,388	47,199
Mechanical room	93	10	930	8760	8,147	100	3	300	8,760	2,628	1,230	10,775
Elevators	93	6	558	8760	4,888						558	4,888
TOTAL											130,718	1,084,215

Gas-Electric Building

Methodology

Step 1: Analysis of Utility Bills

The first step is to define the total amount of energy, and the cost of that energy, which the building is currently using, by energy type.

1. Record monthly utility billing data for a one year period.
2. Place this data on a graph .

Note: *The most recent year usually best represents current operating conditions. If, however, there have been unusual conditions in the building during that year, a different year should be selected. The year can be any 12-month period, but for clarity, the example follows a calendar year.*

A form which can be used to tabulate billing data is provided in Figure 2-1. Information from this form can be used to create a graph of the total energy use and cost over the twelve month period, providing a visual sense of the energy use and energy cost patterns of the building. The graph in Figure 2-2 can be used to manually plot utility billing consumption and cost data. Note that consumption is plotted using the left vertical axis, and cost using the right vertical axis. This data can also be entered into a computer with spreadsheet software and the graph plotted by the same program.

Sample utility data and graphs have been provided in Example 2 for a gas-electric building

Step 2: Determination of the Base Load

Gas Meter

The gas meter for a typical office building which uses natural gas for space heating and service water heating is a highly weather sensitive meter during the winter months. It has a low base load because the service water load is negligible compared to the heating load. Where the building has a significant food service activity, the service water heating load may be a larger proportion of natural gas consumption.

- To determine the monthly base load, examine the pattern of natural gas consumption.
- Take the average gas consumption for the months of April, May, June, and September, provided these are at a reasonably consistent level.

While July and August may have lower gas consumption, this is usually due to the effect of reduced occupancy rates due to holidays.

Electric Meter

The electric meter of a gas-electric building will show weather sensitivity only during the cooling months.

- To determine the monthly base load, take the average of the consumption for the months of November through March.

These months should show a relatively stable use pattern.

Example 2 illustrates the selection of the base load from utility bills for this type of building.

Step 3: Estimating Energy for Heating and Cooling Loads

Gas Meter

- Determine the natural gas consumed annually for space heating by deducting the amount of natural gas consumed monthly for the base load times 6 from the total consumed during the heating months of the year (October - March).
- The sum of these amounts is the total annual natural gas consumption for space heating.

Electric Meter

- Determine the electricity consumed annually for space cooling by deducting the amount of electricity consumed monthly for the base load times six from the total consumed during the cooling months of the year (April - September).

Step 4: Disaggregation of the Base Load

In this step the Base load will be disaggregated into the lighting load and all other loads. Lighting is usually the largest electrical load in an office building.

In order to establish the lighting load, a lighting audit must be conducted.

4.1: The Lighting Audit

1. Walk through the building and record the types and ratings of lamps and fixtures. The building may have a variety of different lamp types and fixture designs, but there will be considerable replication. *A list of lamp and fixture combinations, and the total load for each one, is provided in Figure 2-3 and can assist in categorizing those types installed in the building.*

2. Count the number of each type of fixture in the building. *A format for recording the appropriate information is provided in Figure 2-4..*

3. Insert the appropriate number of watts per fixture or lamp for each type from the information in Figure 2-3.

4. Provide an estimate of the annual operating hours for each category. Base this on the best estimate available, taking into account hours of use per occupied day, weekend and statutory holidays, and management of lights by cleaners and others outside of normal occupied hours.

5. Multiply the number of fixtures of each type, load per fixture (watts) and hours of use to determine the annual energy consumption in kWh. The total energy for all lamps and fixtures in the building is the lighting energy.

4.2 Other Electrical Load

- Determine energy for the remaining portion of the Base load by deducting the lighting energy from the total Base load. This energy will be used for such things as service hot water, lights, HVAC auxiliaries (such as fans and pumps), plug load, etc.

Step 5: Summarizing Energy End-use

- Summarize the energy for each end-use in Figure 2-5. A pie chart can be developed from this data for a graphical presentation.

Example 2: Level I Audit of a Gas-Electric Building

For the purpose of this example, the building is the same as the sample building in Example 1, but uses natural gas for space and service water heating.

Step 1: *Analysis of Utility Bills*

A tabulation of the electrical and gas energy billing data (use, demand, cost) and corresponding graph are provided in Figure 2-8..

Step 2: *Determination of the Base Load*

Gas Meter

From the billing data and corresponding graph, the consumption for June and September is lower than any months except July and August. The consumption for these months is assumed to be the base load, which is only the service water heating load.

$$\begin{aligned} \textit{Monthly Base Load Consumption} &= \textit{Average Consumption for June and September} \\ &= \left(\frac{1{,}168 + 2{,}844}{2} \right) \\ &= 2{,}006\ m^3 \end{aligned}$$

$$\begin{aligned} \textit{Total Base Load Consumption} &= 2{,}006 \times 12 \\ &= 24{,}072\ m^3 \end{aligned}$$

Electric Meter

From the billing data and corresponding graph, the months of February and November have the lowest consumption. The graph illustrates the rise in consumption throughout the summer cooling months.

Average of February and November Consumption

$$\begin{aligned} \textit{Base Load Consumption} &= 150{,}875\ kWh \\ \textit{Total Base Load Consumption} &= 150{,}875 \times 12 \\ &= 1{,}810{,}500\ kWh \end{aligned}$$

Step 3: Estimating Heating and Cooling Consumption from Utility Bills

Gas Meter – Heating Consumption

$$\textit{Total Heating Consumption}$$

$$\textit{Total Consumption (October–March)} - \textit{Base Load Consumption (October–March)}$$

$$= 106{,}885 - (6 \times 2{,}006)$$
$$= 12{,}036 \ m^3$$

Electric Meter – Cooling Consumption

$$\textit{Total Cooling Consumption}$$

$$\textit{Total Consumption (April–September)} - \textit{Base Load Consumption (April–September)}$$

$$= 1{,}112{,}633 - (6 \times 150{,}875)$$
$$= 207{,}383 \ kWh$$

Step 4: Disaggregation of the Base Load

4.1: The Lighting Audit

Figure 2-7 shows the completed lighting audit for this building. Table 1 was used to determine the watts per fixture for each fixture type encountered.

The total lighting load of the building is 1,084,215 kWh

4.2: Other Electrical Load

The "other" load is the remaining NWS load:

$$\textit{Other Load}$$

$$1{,}810{,}500 \ kWh - 1{,}084{,}215 \ kWh = 726{,}285 \ kWh$$

Step 5: Summarizing Energy End-use

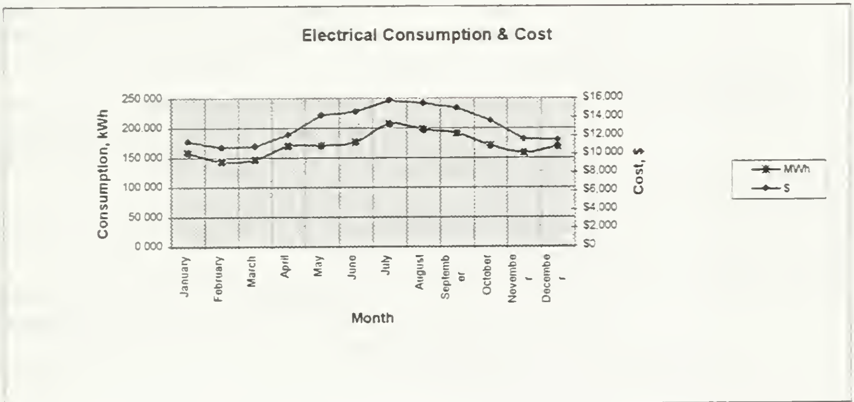
Figure 2-8 shows a summary of the energy end-use breakdown.

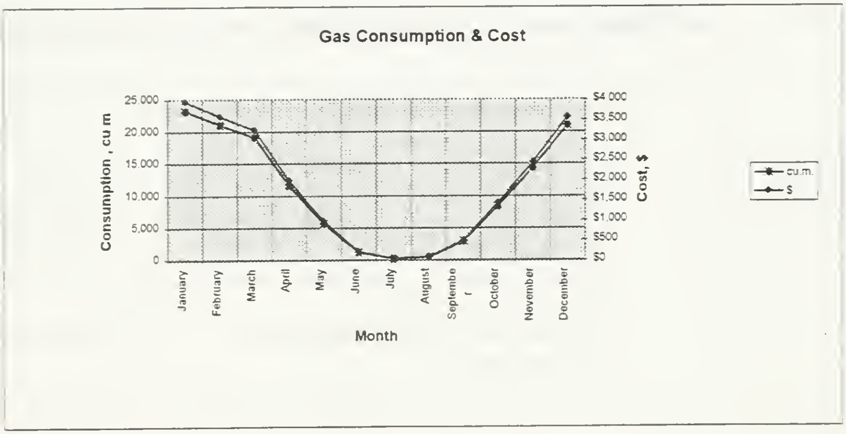
Figure 2-8

EXAMPLE 2: UTILITY BILLING DATA AND ENERGY END-USE BREAKDOWN (GAS-ELECTRIC BUILDING)

UTILITY BILLING SUMMARY					
MONTH	ELECTRICITY			GAS	
	Consumption, KWh	Demand, KW	Cost, $	Consumption m^3	Cost, $
January	157.928	298.8	$11,355	23,223	$3,948
February	143.378	306.0	$10,723	21,076	$3,583
March	146.535	301.2	$10,821	19,079	$3,243
April	170.062	310.8	$12,096	11,602	$1,972
May	170.353	484.3	$14,178	5,613	$954
June	176.289	493.4	$14,579	1,168	$199
July	206.684	469.8	$15,797	132	$22
August	198.040	477.4	$15,461	399	$68
September	191.205	466.7	$14,997	2,844	$483
October	170.326	437.6	$13,620	8,268	$1,406
November	158.371	318.0	$11,605	14,314	$2,433
December	168.926	314.0	$11,493	20,925	$3,557
Total	2,058,097	4,678.0	$166,726	128,643	$21,869

ENERGY END-USE SUMMARY	
ELECTRICITY	
LOAD	kWh
TOTAL LOAD	2,058,097
COOLING LOAD	207,383
LIGHTING LOAD	1,084,215
"OTHER" LOAD	766,499
GAS	
LOAD	cu. m.
TOTAL LOAD	128,643
HEATING LOAD	99,877
OTHER LOAD	28,766





Level II – More Detailed Energy End-Use Analysis

This section describes a more rigorous approach to the energy audit and a methodology for a more accurate determination of space heating and cooling loads and the lighting load. Further disaggregation of the remaining or "other" load is also discussed, along with some of the issues surrounding difficulties in obtaining and measuring accurate audit data.

Step 1: Detailed Analysis of Utility Bills

The first step in the audit process is to identify the typical energy use for the building.

- Electrical consumption, peak electric demand, natural gas consumption (or other fuel) and water consumption are obtained from utility bills.
  - A more accurate look at annual energy use can be made by reviewing past billing data for two or three years of energy use rather than using data for only one year.
  - Year to year fluctuations in use may be caused by equipment service outage for significant amounts of time, short term changes in occupancy levels or occupancy type, tenant time-of-use changes, or changes in office equipment loads.
  - Using data from more than one year will reduce the impact of a single unusual condition or event on the analysis.
  - Where there is a known and uncharacteristic significant energy change in a given year, it is recommended that this year not be used in defining the typical usage pattern for the building.

- When comparing energy data for a number of years, it is necessary to account for changes in weather, monthly billing periods, and utility meter reading practices.
  - Different billing period lengths for any given month may skew the consumption for that month.
  - Weather pattern changes from year to year can have a significant effect on overall building energy use.
  - Utilities may estimate consumption for some billing periods, rather than read the meter every month.
  - Utility data from all years being compared should be normalized for billing period and weather.

It should be noted, however, that only weather sensitive (WS) meters will be affected by changes in weather patterns. *(Refer to Level I for an explanation of WS meters).*

When applied to past years for the purpose of comparing to the most recent year, the weather adjustment effectively simulates what the energy use patterns *would* have been for those years if they had experienced the weather pattern of the most recent year.

- Weather data, specifically Degree Day (DD) data, must be obtained to carry out a weather adjustment.
  - Daily DD data for any region can be obtained from Environment Canada. It is provided at a balance temperature of 18 degrees Celsius.
  - Both Heating Degree Days (HDD) and Cooling Degree Days (CDD) are given.
  - DD data is required for both the year being adjusted and the year being adjusted to (usually the most recent year).
  - If the building is all-electric with a WS electric meter (heated only in winter, cooled only in summer), then an adjustment for both heating and cooling must be done to the same meter.
  - If the building is gas-heated, then an adjustment for cooling must be done on the electric meter and an adjustment for heating on the gas meter.

The following equations are the adjustment equations for weather to be applied to each month of the year being adjusted:

$$\text{Adjusted Use}$$

$$[Use/HDD] \times \left[\frac{HDD}{30} \times \text{days in billing period}\right] + \left[\frac{\text{Base Load}}{30} \times (\text{days in billing period})\right]$$

And/Or

$$\text{Adjusted Use}$$

$$[Use/CDD] \times \left[\frac{CDD}{30} \times \text{days in billing period}\right] + \left[\frac{\text{Base Load}}{30} \times (\text{days in billing period})\right]$$

- *Use/HDD* and *Use/CDD* is obtained using data for the year being adjusted.
  - Specifically, *Use* is plotted against HDD for each heating month (months with HDD only) and the resulting slope of the line plotted is *Use/HDD*.
  - Similarly, *Use* is plotted against CDD for each cooling month (months with CDD only) with the resulting slope of the line plotted being *Use/CDD*.
  - Months with both HDD and CDD are not included because if, in a given month, there are a very small number of HDD and a very large number of CDD(or vice versa), the line on the Use vs HDD (or Use vs CDD in the case of large HDD) will be skewed by this point.

- The Base load of the building is the use at the point where the line on each of these graphs crosses the axis (0 HDD or 0 CDD).
  - The value should be the same on both graphs, however, this is unlikely to happen exactly due to the small number of points plotted.
  - It is recommended that the base load be taken from the HDD graph as there are usually more points. In fact, this base load can be marked on the Use/CDD graph first and the line of that graph plotted from the base load mark through the few points available to obtain the best estimate of the slope for that graph.

- With *Use/HDD* and *Use/CDD* defined for the year being adjusted, the above equations can be applied for each month to obtain the predicted monthly use. It is important to note that if, in a given month, there are both HDD *and* CDD, both formulas should be used and a weighted average taken.

- For electric WS meters, demand should also be adjusted for weather. This is done in a similar fashion as the consumption adjustment:

$$Adjusted\ kW = \left[\frac{kW}{maximum\ DD}\right] \times actual\ kW + Base\ kW$$

- For weather-sensitive meters, adjustment for billing period length only is required:

$$\textit{Adjusted Use} = \textit{Monthly Use} \times \left[\frac{\textit{the number of days in billing period of year being adjusted}}{\textit{the number of days in billing period of year being compared to}}\right]$$

It is important to remember that DD data from Environment Canada comes at an 18°C balance point temperature. Most commercial buildings have balance point temperatures much below 18°C. Typically, the larger the building, the lower the balance point temperature is likely to be. This discrepancy must be accounted for when using the DD data to carry out the above calculations.

A more a accurate and easier way to handle all of the above calculations and account for the balance point temperature discrepancy is to use an Energy Accounting Software Package.

FASER (Fast Accounting System for Energy Recording) is an example of such a program. Once the billing data for all years is entered, FASER automatically graphs use versus weather for all weather sensitive meters and presents options for the user to choose different slopes (each having a statistical R-square value associated with the fit through the data points) and thus different balance temperatures and base loads for each meter. The user can then easily determine a reasonable base load, balance temperature and use/DD for each meter. With these parameters, FASER then calculates the adjusted billing data for the year, accounting for weather, billing period length and balance point temperature discrepancy between the DD data and the building.

A more detailed explanation of the FASER energy accounting software is included in Chapter 4.

If material changes have occurred, years prior to the change cannot be used without a more detailed adjustment made. Such an adjustment would require detailed analysis of performance data and/or engineering data, resulting in a calculation of energy to be added or subtracted from the billing data for the years prior to the change. The adjusted years would simulate the current building and use patterns could then be compared. The most significant material change is likely to be load permanently added or removed; This includes floor space, installation of new air conditioning systems, lighting, building envelope or ventilation changes.

The analysis of the remaining steps in the end-use breakdown process can now be applied to all adjusted years and the results averaged to obtain the typical loads for the building.

Step 2: Estimating Heating and Cooling Loads (WS Meters Only)

- Heating and cooling loads can be estimated from the Use versus Weather graphs discussed in the previous section.
- The heating load for a WS meter is calculated by taking the area under the curve of the WS portion of the graph (i.e., Above the level of the base load).
- The cooling load is found in a similar fashion using the Use/CDD graph.

Step 3: Disaggregation of the NWS Load

- For a gas meter, the NWS load usually consists of service water heating. This is likely to be fairly small for a typical office building unless there are food services, in which case this load can be substantial.
- For an electric meter, disaggregation of the NWS load is more involved. In Level I the NWS load was disaggregated into a lighting load and an "other" load. In this section, the lighting audit will be discussed in more detail as well as methods of further disaggregating the rest of the NWS load.

3.1: Performing a Lighting Audit

It is advantageous to the post-audit process of determining feasible energy savings measures for a building to perform a more rigorous lighting audit than was presented in Level I. The Level I audit *can* still be carried out, however, many more issues must be considered throughout the process.

- Pay more attention to the ballast types. There a significant number of different ballast types, particularly for T-8s. Actual ballast types should determined by direct examination of a sample of fixtures, and the inventory of ballasts for replacement should be also checked. More detailed information on energy use should be obtained from the manufacturer for the specific ballast types for compact fluorescent lamps, metal halide and mercury vapour lamps.

- Assess more accurately the hours of use and diversity (percentage of time each fixture is on per day contributing to the peak demand). This can be done by interviewing the building operator and the tenants and by noting whether the lights are on sensors or on switches. If the lights are on switches, speaking with tenants is key to estimating the diversity. Obtaining typical office hours for each tenant also helps in estimating hours of use/year.

- Record the frequency of lamp burn-outs. The overall average number of burn-outs will decrease the existing lighting load.

- Include outside lights in the audit.

- Consider architectural details in order to facilitate the energy-efficiency measure assessment stage. The manner in which the fixtures are mounted should be recorded, the type of fixture, the lens type and the general condition of the fixture should also be recorded. Wiring and circuiting information, including location of power sources, will facilitate the assessment of the feasibility of implementing controls. All room dimensions, and use of the space should be recorded. Measurement of light levels with a light meter will help determine whether a re-design is necessary as part of a new measure.

- Note the current electrical rate structure, as well as how the hours of use overlap with that structure (i.e., the amount of on and off-peak use) in order to later determine the financial pay-backs to implementing new energy-efficient lights.

3.2: Disaggregation of the Remaining NWS Load

The remaining NWS electric load can be further disaggregated into HVAC auxiliaries and plug load.

HVAC Auxiliaries

HVAC auxiliaries essentially consist of all pumps and fans.

- To calculate the total auxiliary load, an inventory of all equipment must be taken and an evaluation made of diversity and hours of use.
  - Collecting nameplate data of horsepower, volts and amps is one way of gathering the information, however, an estimate of motor loading must then be applied to each unit.
  - The most accurate method is to measure the power consumption (watts) with the appropriate meter. As such meters are very expensive, it is recommended that a specialist be hired to conduct this type of an audit. If the rate structure has a penalty for power factor, this should also be determined by measuring the volts and amps.
  - A diversity factor should be estimated for all loads and hours of use per year for each load obtained from the building operator.

When this data is compiled, each load can be multiplied by its diversity factor and by the hours of use to arrive at the kWh of use for each load. The sum of the kWh for all loads represents the HVAC auxiliary load for the building.

Plug Load

Plug load makes up the remaining portion of the NWS load. It includes such things as plugs, computer, printers, fridges, stoves, photocopiers, clocks, pop machines, electronic equipment, coffee makers, etc.

- A plug load survey can be done to estimate the total value of the plug load. This entails recording the nameplate of measured kW draw on each load. However, diversity plays a very large role in establishing the actual plug load and it is very difficult to estimate. Also, the actual load may be quite different than the nameplate, particularly in the case of computers which are nameplate rated for the power supply capability which usually has excess capacity.
- Due to the difficulty in measuring actual loads and in estimating diversities, it is recommended that the plug load be calculated by default. That is, assume the plug load makes up the remaining portion of the NWS load.

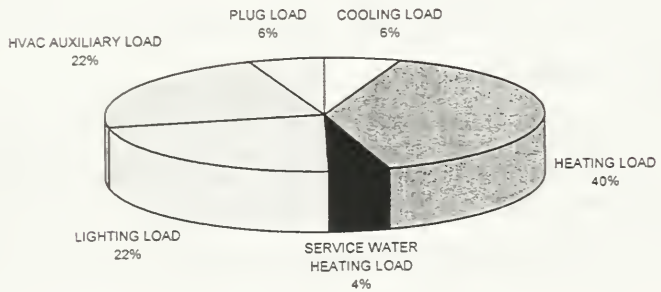
A sample summary table of the end-use break-down for a gas-electric building is provided in Figure 2-9 along with a sample pie chart for further illustration.

FIGURE 2-9: SAMPLE END-USE BREAKDOWN: ELECTRIC/GAS BUILDING

LOAD	ekWh*
TOTAL GAS AND ELECTRIC LOAD	3,575,000
COOLING LOAD	200,000
HEATING LOAD	1,417,500
SERVICE WATER HEATING LOAD	157,500
LIGHTING LOAD	800,000
HVAC AUXILIARY LOAD	800,000
PLUG LOAD	200,000

* Gas has been converted to ekWh in order to plot all energy on the same graph

SAMPLE END-USE BREAKDOWN: ELECTRIC / GAS BUILDING



2.2 The Water Conservation Audit

Water consumption in an office building can be divided into two categories: "domestic water" used for washing, cleaning and sanitation, and "process water" used for such things as cooling tower makeup, once through cooling, and irrigation. A detailed audit gives an accurate estimate of current use and potential savings and will analyse the savings potential based on age of facility, demographics, occupancy, condition of equipment, and historic water consumption patterns.

Step 1: Analysis of Utility Bills

The first step in a water audit is to examine utility water bills.

1. Document the consumption and the cost over a 12 month period.
2. Project this data on a graph. The Energy Audit Section includes a form for recording billing data. Figure 2-10 of this section can be used to record estimated consumption and cost for the 12-month period chosen. The table can be used to look for seasonal variations which can be attributed to certain end-uses such as cooling tower makeup water in the summer.
3. For a more detailed audit, sub-metering of some major uses, or sub-metering of a sample of other uses such as toilets, can be very useful in identifying where the water is consumed. Many water conservation companies have the equipment to undertake sub-metering.

Step 2: Audit Report

Through sub-metering and/or careful analysis of utility billing data, it is possible to outline each individual water end-use annual consumption. This information should then be assembled into a report. The sum of the consumption for each end-use must equal the total annual metered consumption for the building.

A sample audit report is included in this section.

Figure 2-10

WATER USE BREAKDOWN	m^3	$	% of total
Estimate of Domestic Water Usage			
Toilets, Flushometer			
Toilets, Tank			
Urinals, Flushometer			
Urinals, Tank			
Showerheads			
Faucets			
Other			
Estimate of HVAC Water Usage			
Cooling Towers			
Once Through Cooling			
Humidification			
Estimate of Irrigation Water Usage			
Other Water Usage			
TOTAL FACILITIES USAGE			

2.3 The Waste Audit

One of the best means of gaining a better understanding of the waste stream, and identifying opportunities to reduce energy, water and waste sent for disposal is to conduct a waste audit.

The purpose of a waste reduction audit is four-fold:

1. Identify current waste disposal costs
2. Identify the type and quantity of different wastes generated throughout the building and where they are generated
3. Identify materials that can be reduced, reused, recycled
4. Help in the development of a waste reduction strategy that helps you get the most "bang-for-the-buck", i.e., reduces operating costs and ensures maximum participation

The desired level of accuracy of information about the waste stream (i.e types and quantities of waste) will impact the type of waste audit performed. Given the many demands placed on property management staff, there may be limited time and resources available to conduct a time-consuming, waste sampling and sorting procedure just to gather more information about the waste stream. A visual audit is sometimes sufficient to obtain the information required for preliminary waste reduction planning.

A visual audit, while not as accurate as the traditional, labour intensive waste sample and sort assessment, will provide useful information to help reduce the garbage that office buildings generate and save money. Up to 70% of the waste generated in your building is generally paper waste. Most of this can be recycled, with only a fraction not recyclable.

A visual waste audit involves:

- a walk through of all area of the facility
- visually estimating the volumes and composition of waste generated in different areas
- estimating the weights of the waste materials using density conversion tables.

How to Conduct a Visual Waste Audit

A set of worksheets are provided in the guidebook to help with a visual audit. Refer to the Waste Audit Worksheets 1 through 7 in this chapter.

To begin the visual waste audit you will need to decide:
- how many samples to use
- where to sample
- when to sample
- how often to sample.

Several waste sampling options are available. You may choose to sample:
- at each significant location (i.e. major activity) (typically used in operations where waste is more diverse
- at "end of pipe" (i.e disposal bin or waste pile) (typically used if you believe your composition is consistent throughout all areas of your facility, or if you have a very small operation)

Whether you choose to sample in one or several locations, you will estimate your waste composition by:
- examining the total amount of waste generated in the area (recommended only if the office building is small), or
- selecting a representative sample of waste from the area (a suitable approach if the office building is large).

Exercise The following exercise will help you complete the worksheet specific to a visual waste audit *(See Figures 2-11 and 2-12).* The visual assessment method is only useful when you have volume data.

For each location (or activity) sampled:
- Record the total volume of waste generated (per day or week) *(Column A).*
- Record the volume of your sample *(Column A).*
- Record the types of waste in the sample and percent composition of each material (by volume) *(Column B).*
- Calculate the volume of each material in the sample. Multiply the percent composition by the sample volume. *(Column C).*
- Convert volume to weight *(Column D). (Refer to conversion tables listed in Appendix)*
- "Factor up" convert the weights of waste in your sample to a daily, weekly, monthly or annual total *(Column E).*

Example A 1 m^3 container of uncompacted garbage is filled with 50% OCC and 50% food waste. The different material densities must be taken into account to calculate the correct waste composition.

0.5 m^3 OCC @ 55 kg/m^3 = 27.5 kg (10.4%)
0.5 m^3 food @ 475 kg/m^3 = 237.5 kg (89.6%)

Figure 2-11

Basic Visual

Location/ activity	A. Volume of waste *(per day or week)*	Type of waste in sample	B. % Composition of each waste category by volume[1]	C. Volume of each material in sample *(BxY)* *(unit.....)*	D. Weight of each material in sample[2]	E. Weight of material in location *(DxZ/Y)*
Cafeteria	*Total volume of bin* *(day/week)* Z *Sample volume* *(day/week)* Y				*Weight/day of sample*	*Weight/day in location*
Production	*Total volume of bin* *(day/week)* Z *Sample volume* *(day/week)* Y				*Weight/day of sample*	*Weight/day in location*

[1]Ensure that percent composition ≠>100%

[2]See Density Conversion Table in Appendix

Figure 2-12

Basic Visual

WORKED EXAMPLE

Location/ activity	A. Volume of waste *(per day or week)*		Type of waste in sample	B. % Composition of each waste category by volume[1]	C. Volume of each material in sample *(BxY)* *(unit.....)*	D. Density *(kg/m³)*	E. Weight of each material in sample[2] *(CxD)*	F. Weight of material in location *(DxZ/Y)*
Cafeteria	*Total volume of bin*		Food Waste	40%	0.2 m^3	356	71.2	284.8
	2 m^3 *(day/week)*	Z	Ferrous Metal	5%	0.025 m^3	208	5.2	20.8
			Glass	5%	0.025 m32	356	8.9	35.6
			OCC	25%	0.125 m^3	74	9.2	37.0
	Sample volume		Plastic	25%	0.125 m^3	30	3.8	15.2
	0.5 m^3 *(day/week)*	Y					*Weight/day of sample*	*Weight/day in location*
							98.3 kg	393.2 kg
Production	*Total volume of bin*		OCC	50%	10 m^3	74	74	1,480
	40 m^3 *(day/week)*	Z	Wood Pallets	25%	5 m^3	170	850	1,700
			Light Ferrous Scrap	50%	1 m^3	208	208	416
			Plastic Wrapping	20%	4 m^3	30	120	240
	Sample volume							
	20 m^3 *(day/week)*	Y					*Weight/day of sample*	*Weight/day in location*
							1,918 kg	3,836 kg

[1]Ensure that percent composition ≯100%

[2]See Density Conversion Table in Appendix

- If your waste is compacted, calculate the uncompacted volume by multiplying the size of container by the compaction ratio (usually 4:1, or ask your hauler or equipment supplier). For example, a 2 m^3 bin with a 4:1 compaction ratio is equal to 8 m^3 of uncompacted waste. *(A Density Conversion Table is provided in Figure 2-13 for sample compaction densities for various materials).*

- A quick way to estimate waste volumes is to estimate the proportion of one or two categories of waste that appear to be the largest. Then decide what percentage of waste is left over and divide that amount between the residual materials.

- Taking photographs or a video during the walk-through and visual assessment can assist you to document or re-create the audit at a later date.

Some tips when conducting a visual audit include:

- Capture a normal or typical sample of waste from each tenant and activity area. Plan the visual audit to avoid events or holidays (i.e., delivery days, holidays, in-house events) that will skew the results. Consider choosing a sampling period that can be repeated in subsequent years.

- Develop a visual assessment that samples over a period of time (to increase the level of information and accuracy). A scheduling period may include one day a week over a four week period, two consecutive days over a two week period or every day for a week.

- Determine the percentage that your samples represent of the total waste generated for that day. Make sure that it represents the different activities in the building and the different tenants.

- Schedule the visual assessment at the end of the day or when the waste bins are fullest. If collection does not occur on a daily basis then schedule the assessment prior to collection.

- Prepare separate worksheets for each activity area or tenant. This will help to identify unique waste generation patterns and develop a more customized waste diversion program. Also, communications and monitoring can be fine-tuned to the interest of the tenant, which will help to engage them more in the process.

- Wear appropriate safety clothing, such as latex gloves, safety glasses and old clothing to permit sorting through the garbage without concern about safety or injury.

Conducting an Audit on Procurement and Purchasing Practices

Many materials that end up as waste in an office building originate from the purchasing department (i.e. photocopy paper, pens, office supplies, etc.). Knowledge of procurement practices is an essential part of a thorough waste audit.

The objectives of a procurement audit are:
- to identify opportunities to reduce or reuse waste by making informed purchasing decisions
- to identify methods by which purchasing policies can be modified to minimize waste generation
- to identify opportunities to increase the recycled content of purchased materials and the recyclability of materials that cannot be reduced or reused.

The procurement audit should cover three main areas:
- transport packaging used to protect products during shipment
- product packaging
- the product itself

During the procurement audit, a visual inspection and review of purchasing activities should be undertaken, including:
- review of purchasing records/files with those who actually do the purchasing
- conduct visual inspection of supply cupboards and storage areas
- conduct a visual inspection of the shipping/receiving area to assess the quantity and type of transport packaging associated with products and supplies;
- identify service contractors and determine types and quantities of products and supplies procured for office operations and service contracts (e.g. cleaning and building contractors).

A sample procurement audit worksheet and questionnaire is provided in the Appendix Section. It is recognized that the products and materials purchased vary widely from organization to organization, so this sample is intended to serve primarily as a possible framework for designing your own form.

A tip when conducting a procurement audit

- You can save time by focussing initially on the top 20% of products you purchase. Conducting a thorough review of all products and materials purchased may be a massive undertaking. In most cases, however, the first 20% of your materials (listed in descending order by total cost) are probably fairly representative of most of the materials that you purchase.

Figure 2-13

Density Conversion Table

Material		Uncompacted Kg/m^3	Compacted Kg/m^3
Paper	Newsprint	297	428-600
	Ledger Paper	297	450-550
	Computer Printout	297	779
	Mixed Office Paper	238	449
	Corrugated Cardboard	74	312-416
	Boxboard	178	498
Metals	Ferrous Cans: Whole	89	
	Ferrous Cans: Flattened	208	240-289
	Ferrous Metal	208	
	Aluminum Cans: Whole		
Glass		356	
Organics	Yard Waste (mixed)	103	222
	Food: Kitchen Waste	456	
	Grass Clippings	330	
	Leaves	130	
Wood	Loose Dimensional Lumber	145	
	Pallets	170	
	Sawdust	288	
	Wood Chips	298	
	Shavings	241	
	Trimmings	577	
Plastics	PET	22	306
	HDPE	29	238
	Polystyrene	10	
	Other Plastics	10-30	417
Textiles		179	286
Garbage		250	

When reviewing the products/items currently purchased, the following questions should be asked:

Reduction and Reuse

______ Is the product/material you purchase/produce really needed? Could you do without all or part of it?

______ Is the product you purchase/produce designed to be reusable?

______ Can the package in which the product is delivered be reduced? Can it be reused?

______ Can you work with the supplier to take back the packaging and/or product after its use?

Recycling

______ Can the product be recycled locally?

______ Can the packaging in which the product is delivered be recycled locally?

Recycled Content

______ Does the product/package contain post-consumer recycled content?

______ Does the product/packaging comply with Environmental Choice program guidelines?

Energy Conservation

______ Does the product have the latest energy conservation features?

______ Does the product comply with energy efficiency programs, such as Energy Star program, Power Smart program, Environmental Choice program guidelines?

Reduced Toxicity

______ Is an alternative non-toxic product available?

______ Does the product comply with Environmental Choice program guidelines?

Once you have completed your procurement audit and are aware of those items that are ultimately transformed into significant volumes of waste, you can proceed to identify opportunities to change your procurement practices to reflect the principles of reduction, reuse and recycling.

Waste Audit — Worksheet 1

Useful Background Data

Date ______________________________

Name of Person Completing Form ______________________________

Position ______________________________

Office Address ______________________________

____

Types of Tenants and their Operations

____

____

____

____

____

____

Number of employees/staff in facility ______ *(full time)*

Size of facility (floor area, number of floors)

____

Number of operational days in a year __________

Standard Solid, Non-hazardous Waste Material Categories

Paper

______ OCC (cardboard)
______ ONP (newspaper)
______ fine paper
______ computer paper
______ boxboard
______ mixed paper (including kraft paper, manila envelopes

Glass

______ bottles/jars
______ pane glass
______ other glass (i.e. wine glasses)

Scrap Metals

______ ferrous
______ aluminum
______ other precious metal (cooper, etc.)
______ other non-ferrous metals

Plastics

______ PET (pop bottles)
______ HDPE (jugs)
______ LDPE (stretch wrap)
______ composites
______ polystyrene (PS)
______ film plastic (shrink wrap)
______ PVC
______ other

Organic (non-hazardous)

______ food waste
______ vegetation
______ leaf and yard waste
______ brush

Construction/Demolition Waste

______ brick
______ drywall
______ concrete
______ wood
______ steel
______ rubble
______ topsoil/earth
______ land clearing (trees, vegetation)
______ asbestos
______ wire/plastic cable

Miscellaneous Wastes

______ rubber
______ tires
______ wood
______ textile/fabric
______ composite materials

Distinct Waste Generation Sites

Identify the areas within your facility where distinct types of waste are generated.

Location/Department (e.g. cafeteria, administration, shipping/receiving etc.)	Typical Wastes	Separate Audit Required *(Y/N)*

Waste Audit — Worksheet 4

Basic Visual

Location/ activity	A. Volume of waste *(per day or week)*	Type of waste in sample	B. % Composition of each waste category by volume[1]	C. Volume of each material in sample *(BxY)* *(unit.....)*	D. Weight of each material in sample[2]	E. Weight of material in location *(DxZ/Y)*
Cafeteria	*Total volume of bin* *(day/week)* Z *Sample volume* *(day/week)* Y				*Weight/day of sample*	*Weight/day in location*
Production	*Total volume of bin* *(day/week)* Z *Sample volume* *(day/week)* Y				*Weight/day of sample*	*Weight/day in location*

[1]Ensure that percent composition ≯100%

[2]See Density Conversion Table in Appendix

Annualize Data

Material	Generating Station	Total weight/week *(unit......)*	x ....wks = Total weight/year *(unit......)*	Total weight/year *(tonnes)*
	1.			
	2.			
	3.			
	4.			
	Subtotals			
	1.			
	2.			
	3.			
	4.			
	Subtotals			
	1.			
	2.			
	3.			
	4.			
	Subtotals			
	1.			
	2.			
	3.			
	4.			
	Subtotals			

Procurement Audit

Product Type	Current Product Used	Identify Current Packaging	Alternatives Available				Immediate Actions to Pursue
			Increase Recycled Content	Encourage Waste Reduction	Promote Energy Conservation	Reduce Toxicity	
Office Supplies							
Office Paper *(including computer paper)*							
Envelopes							
Folders							
Storage Boxes/ Magazine Boxes							
Fax Paper							
Toner Cartridges							
Pens, Pencils and Markers							
Other office accessories *(name)*							
Cleaning Products and Accessories							
Hand Soap							
Janitorial Cleaners							
Detergents							
Toilet Paper							
Hand Towels							

Product Type	Current Product Used	Identify Current Packaging	Alternatives Available				Immediate Actions to Pursue
			Increase Recycled Content	Encourage Waste Reduction	Promote Energy Conservation	Reduce Toxicity	
Office Equipment and Accessories							
Photocopiers							
Computers							
Printers							
Fax Machines							
Lamps/Light Bulbs							
Furniture							
Carpeting							
Appliances							
Landscape Maintenance							
Fertilizers							
Herbicides/Pesticides							
Miscellaneous							
Paints							
Aerosols							
Batteries (small cell)							

Worksheet 7 - Procurement Audit

1. What environmental considerations do you now incorporate in making purchasing decisions?

2. Do you have a purchasing policy and does it contain environmental considerations?

3. If you answered "Yes" to No.1 or 2 above, what verification process do you follow to make sure the product(s) meets the supplier's/manufacturer's environmental claims?

4. Do you participate in a trade/industry association that coordinates efforts on behalf of its members to promote environmentally sound products and purchasing practices?

5. Do you involve suppliers/dealers in any environmental initiatives? How?

6. Where in your organization is responsibility for purchasing located? Is it centralized?

7. Do you have a corporate policy that addresses purchasing and the environment? If yes, summarize briefly.

Recommend Priority Action

Completed By: Date:

Approved By: Date:

3. The Implementation Phase

There are some essential elements to the implementation and maintenance of a resource conservation and waste diversion strategy. Ignoring any element will reduce the success of the program. Following these principles will ensure that occupant and staff efforts are rewarded with a program that works.

- ***Ensure that occupants and senior management are committed to the program.*** It makes a real difference to the success of a program if the building occupants are on-board, management is supportive of the efforts, and employees know that the program has top-level support. Top-level staff also have the ability to allocate funds and staff time to ensure the success of a program.
- ***Conduct a thorough audit.*** This is critical to the monitoring process. Without an accurate indication of how much of each type resource is consumed and material is in the waste stream, the success or failure of conservation and waste reduction efforts cannot be effectively measured.
- ***Design your program to be as simple and convenient as possible.*** This will encourage participation and minimize opportunities for technical or organizational breakdown. In most cases, relatively straightforward, low-cost measures are responsible for the bulk of cost reduction. Significant reduction and savings can be easily and effectively achieved. To attain very high levels requires more effort.
- ***Create a sense of "pride and ownership" in each program.*** It is good practice to involve tenants/occupants, management and employees from all functional areas of the facility in designing the program, and to ask for input and feedback from those who will be directly affected. Involvement creates a sense of ownership in the program, along with increased participation. One way to achieve this is to form a "Green Committee" in the building, comprised of enthusiastic occupants who can speak about successes and challenges encountered in their office and take information and strategies back to the office for implementation.
- ***Emphasize occupant and employee education and communications.*** Occupant and employee education is one of the most important components of any conservation or waste reduction program. Most measures rely on a continuous flow of information to staff. Establishing pride in one's accomplishments through an effective education and communication strategy will prompt continued participation in the program.
- ***Maintain continuous monitoring and evaluation.*** A resource conservation and waste reduction program is dynamic; conditions change, new technologies evolve, and the goals and priorities of the organization may shift over time. The program will need regular review and updating as new options are developed or identified. Continuous monitoring is crucial if results are to be quantified, problems resolved and new opportunities identified.

Economics of Conservation Measures

The decision to implement energy conservation measures is usually based on the expectation of a worthwhile return on the invested cost of the measure.

The calculation of the simple payback of any measure (without interest or operations and maintenance savings taken into account) is:

$$Simple\ Payback = \frac{Cost\ of\ Measure}{Annual\ Cost\ Savings}\ (years)$$

The simple payback is useful for comparing the potential cost/benefit of two or more measures, but it does not take into account all the factors involved in either the cost or the benefit. Figures 3-1 and 3-2 present a graphical picture of these factors.

- The purchase and installation of a conservation measure represents an initial investment which must be made before savings will accrue.
  - A measure which is somewhat complex, requiring time to design, secure, install and commission, would be represented by the *Cumulative Measure Cost Line.* The continuation of this line horizontally represents the situation where no interest is applied to the cost of the measure.
  - Once installed and paid for, on the assumption that the money was borrowed to finance the measure cost, interest will accrue over them and must be added to the measure cost. This is represented by the *Cumulative Measure Cost plus Interest Line.*
  - Also once installed, the measure should begin to produce cost savings, generally through reduced utility costs for energy or water.
  - As these accumulate over time, they are available to repay the investment in the measure.
    - The point where the rising *Cumulative Savings Line* meets the horizontal *Cumulative Measure Cost Line* is the Simple Payback in years.
    - The point where the *Cumulative Savings Line* meets the *Cumulative Measure Cost plus Interest Line* is the Payback with Interest in years.

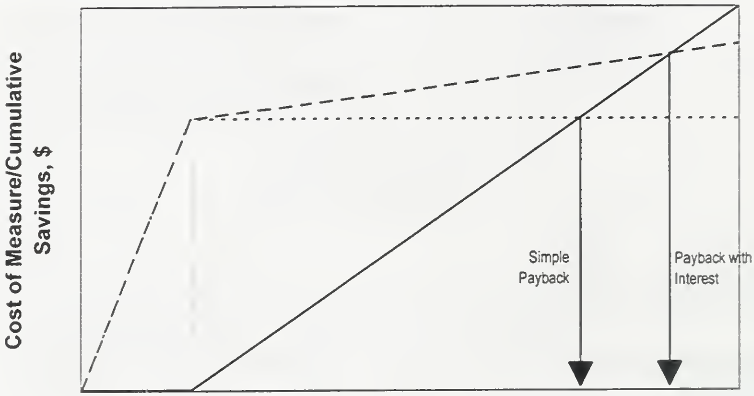
- The implementation of a conservation measure usually involves the renewal of a building component or system which is at or near the end of its useful life.
  - Since the component or system will require replacement at some time in the near future, a more accurate estimate of the payback would include deducting the cost representing the renewal from the cost representing the total energy efficient measure cost.
- As an example of this principle, consider the case of the replacement of a fluorescent light fixture, 2-lamp type, originally installed in a 20 year old office building.
  - Replacement will be necessary for renewal or upgrade reasons within two to four years, with either a fixture using currently available standard technology, or with one using energy conserving technology.
  - The incremental savings attributable to the energy efficient fixture will be $12.00.

This situation is described in the following table:

Net depreciated value of existing fixture (10% of new value)	$10.00
Cost of standard technology replacement	$100.00
Cost of energy efficient technology replacement	$120.00
Annual energy cost savings of energy efficient fixture	$12.00
Simple payback of measure ($120.00 ÷ $12.00)	10 years
Incremental payback of energy efficient fixture [($120-{$100-10}) ÷ 12]	2.5 years

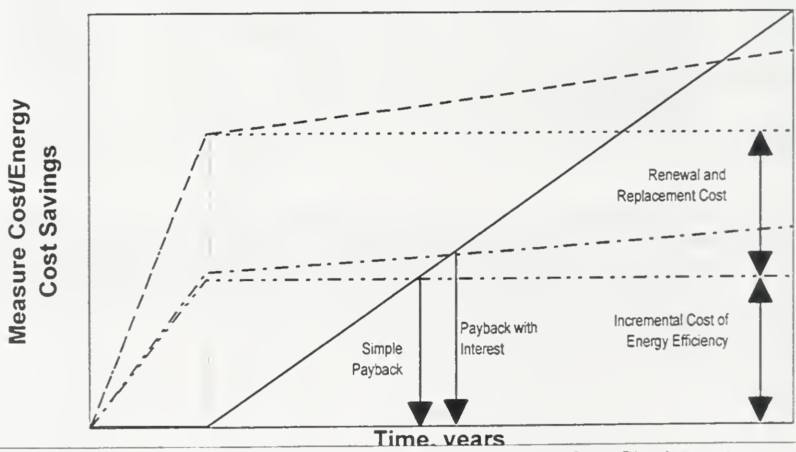
The overall effect on the consideration of payback periods for resource conservation measures is shown in Figure 3-2. The payback of energy efficient measures is significantly lower, and well within the payback criteria of even the most conservative building owners and managers, when the renewal component is separated from the total measure cost.

Figure 3-1: Economics of Conservation Measures (1)



- - - - - - Measure Cost   — — — Measure Cost Plus Interest   ——— Cumulative Savings

Figure 3-2: Economics of Conservation Measures (2)



- - - - - - Measure Cost   — — — Measure Cost Plus Interest
——— Cumulative Savings   — · · — Cumulative Net Cost of Measure
— · — · Cumulative Net Measure Cost + Interest

3.1 Energy Measures

The selection of specific energy measures is dependent on a number of factors, including capital investment, energy cost savings, simple payback period, interest and carrying charges, and specific replacement and upgrade requirements of the building. The information in Figures 3-3 and 3-4 provide guidance for typical energy consumption and cost for the major end-uses, and a target level which can be achieved through careful selection of both measures and energy efficient operations and maintenance.

The selection of measures for typical office buildings have been assembled into a set of "ladders" of measures for ease in their selection. These are presented for Lighting, Chillers and Fans and Pumps. Characteristic improvements are detailed below.

a) *Energy for Lighting*

Many buildings constructed in the '60s and 70s used fluorescent fixture and lamp configurations which resulted in two F-40 lamps for each 25 ft^2 ($2.3m^2$) module. This provided light levels of 100 foot-candles (fc or 1076 lux) for an input of 3.7 W/ft^2 (40.0 W/m^2). The substitution of energy saving (34 watt) lamps has been adopted in many cases which reduced the energy to 3.2 W/ft^2 (34.4 W/m^2).

Newer buildings have opted for the Illuminating Engineering Society of North America (IESNA) guideline for office standard light level of 50 fc (530 lux) by using one two lamp fixture for every second module and energy efficient magnetic ballasts. With the advent of a computer at every workstation, lighting fixtures which reduce glare on video screens become an important consideration in retrofitting lighting.

With the advent of electronic ballasts and T-8 lamps the corresponding energy levels are:

Lamp	Ballast	Energy/ Fixture	W/ft^2	(W/m^2)
F-40	Magnetic	93 W	1.86	20.0)
Energy Saving	Magnetic	72 W	1.44	(15.5)
T-8	Electronic	60 W	1.20	(12.9)

Figure 3-3: Relative Energy Use of Building Systems

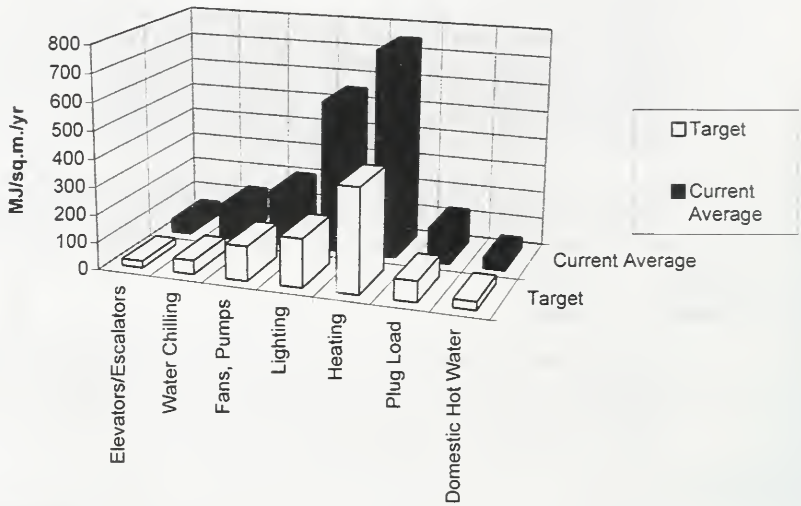


Figure 3-4: Relative Energy Cost of Building Systems

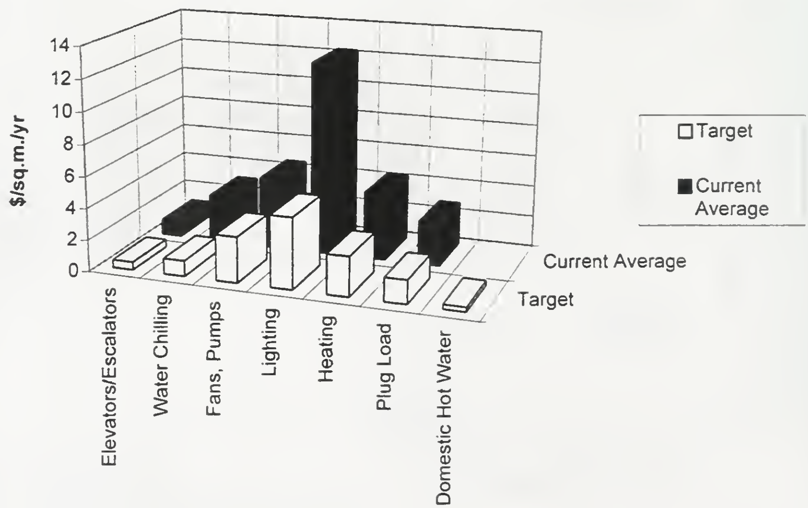
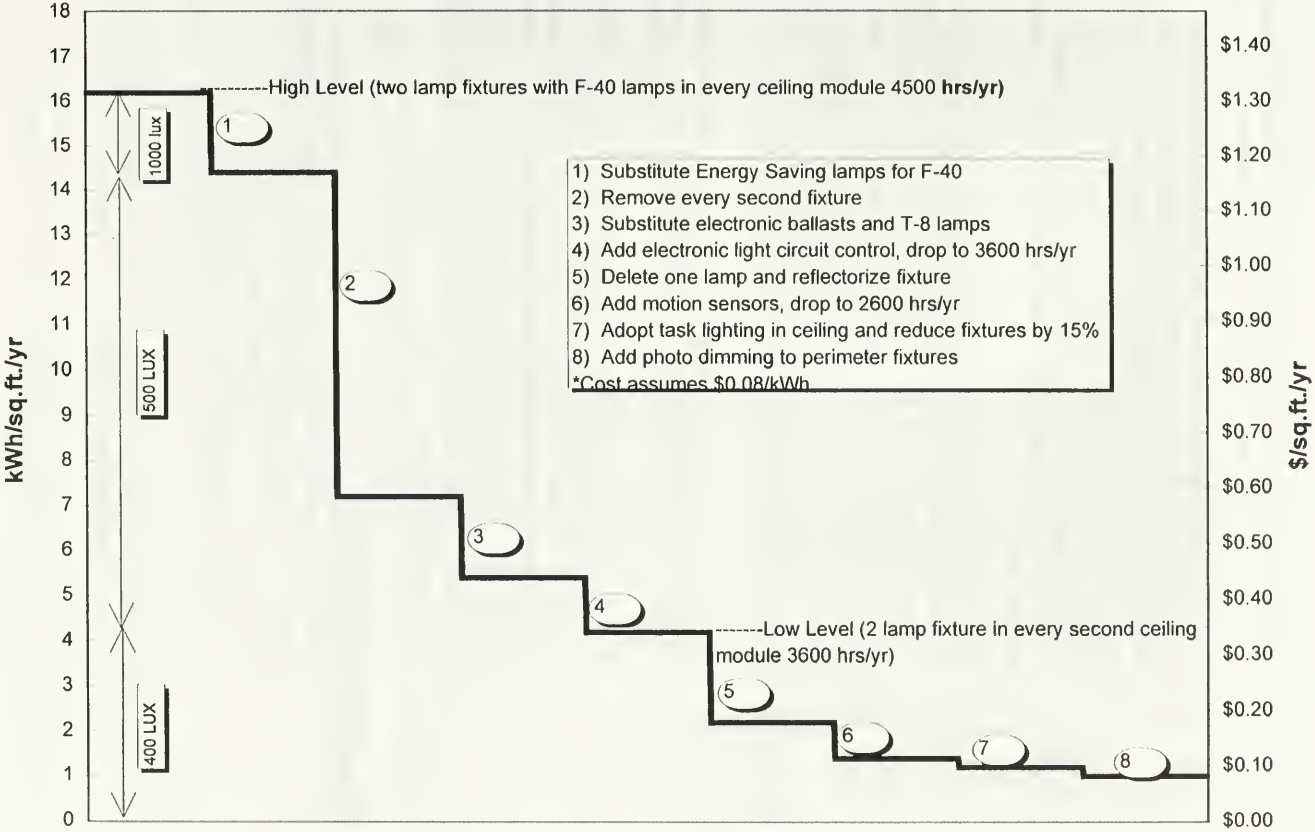


Figure 3-5: IMPACT OF MEASURES ON LIGHTING ENERGY USE & COST



Buildings of the future may provide light levels averaging 37.5 fc (400 lux) using one reflectorized T-8 lamp per fixture per two modules. The lower general lighting level is becoming preferred for applications using computers, which helps to reduce glare. The energy can then be as low as 0.6 W/ft^2 (6.5 W/m^2).

A way to have levels in the range of 500 lux at 0.6 W/ft^2 (6.5 W/m^2) with 15% fewer fixtures is to locate the fixtures directly above the task allowing two single lamp fixtures per task. This will require regular fixture moves as workstations are realigned. This concept has proven cost effective, however, at buildings such as the ICI office in North York and the Bell Trinity Square office in downtown Toronto. With this arrangement the 500 lux will not be uniform but remains within IES standards which permit lighting subsidence up to 35% in non-work areas.

Much of the office lighting is required after hours for cleaners who may work until midnight in larger buildings. This, together with a regime which turns lights on at 7:00 a.m., results in 4500 hrs/yr of operation. The use of central electronic switching can reduce this to 3600 hrs/yr. Adding motion sensors may further reduce this to 2600 hrs/yr.

The measures required to reduce lighting from high to low energy consumption and on to future levels are described in Figure 3-5. The measures are shown in their most logical order by way of a staircase. Savings are generated by a reduction in lighting level, by reducing hours of operation, and by using more efficient fixtures.

The savings for task lighting, motion sensors and perimeter lamp dimming are too small to be cost effective. However, they will become more viable if carried out higher on the ladder. Each step in the ladder assumes that all previous measures have been carried out.

The energy cost savings for reducing lighting from the high level ($1.30/$ft^2$/yr) to the low level ($0.35/ft^2/yr) are dramatic, as is the very low energy cost possible with future lighting ($0.10/$ft^2$/yr). For each kWh/$ft^2$/yr of lighting reduction there can be as much as 0.5 kWh/ft^2/yr savings possible in the operation of cooling, including chilled water or direct expansion cooling, ventilating and circulating fans, chilled water pumps, and heat rejection fans and pumps. These additional savings must be taken into account when testing the cost effectiveness of lighting changes. Lighting thus becomes the lynch pin in the progression of office conservation measures.

b) Energy for Heating

For most office buildings, heating is the greatest user of energy. Except for all electric buildings, the cost impact of heating, however, is reduced because of the lower unit cost of natural gas, other fossil fuels, or central steam.

- At $0.19 per cu m and 70% combustion efficiency, heat from natural gas costs $0.027/ekWh.
- At $10.00 per 1,000 lbs., heat from central steam costs $0.034/ekWh. This compares with electricity which may range from $0.08 to $0.15 per kWh.

A theoretical calculation of heating for typical office buildings with 3880 Celsius degree days (7000 Fahrenheit DD - typical for Toronto or London) would find the following heating requirements.

Item	Single Glazed @ 40% of Wall		Double Glazed @ 40% of Wall	
	$MJ/m^2/yr$	$kWh/ft^2/yr$	$MJ/m^2/yr$	$kWh/ft^2/yr$
Envelope	200	5.3	350	9.3
Infiltration @ 1 change every 4 hrs	90	2.3	90	2.3
Envelope plus infiltration	290	7.6	440	11.6

Yet the average heating load is 750 $MJ/m^2/yr$ (19.5 $kWh/ft^2/yr$). The difference might appear to be ventilation. However, ventilation at 20 CFM/person is unlikely to exceed 100 $MJ/m^2/yr$ (2.5 $kWh/ft^2/yr$) at -20°C.

The cooling effect of ventilation or outside air is available to counteract internal loads at levels such as:

	$MJ/m^2/yr$	$kWh/ft^2/yr$
Lighting	58	1.5
Fans/Pumps	29	0.75
Computers	23	0.6
Totals	**110**	**2.85**

Thus, the introduction of outside air at recommended levels should not become a heating factor in an average office building.

The additional heating energy used in offices results from:
- Wall insulation at less than R-10 (1.8 W/m^2)
- Infiltration at greater than one air change every 4 hours
- Windows at greater tnan 40% wall area
- Reheat for temperature control

When infiltration is excessive, simple measures can be employed to reduce stack effect with better entrance doors and better penthouse sealing. More expensive measures for caulking and sealing walls and windows may be needed where leakage has become excessive.

The largest problem may be the amount of reheat used for temperature control. This is a function of building control and requires expert attention to address this function.

In almost all HVAC systems the amount of reheat can be reduced. In some it can be eliminated. Future systems will require no reheat for temperature control. Future buildings will have walls insulated to at least R-15 (2.7 W/m^2), and windows insulated to at least R-3 (0.5 W/m^2).

Future buildings should only consume energy for heating at about 375 $MJ/m^2/yr$ (9.8 $kWh/ft^2/yr$). Existing buildings can reduce heating energy by up to 30% by careful managing of stack effect and reducing reheat for temperature control.

c) *Energy for Fans and Pumps*

Large office HVAC systems in the '60s and '70s used constant speed central fans and pumps. In the '80s constant speed fans gave way to variable air volume and many fans became compartmentalized to serve one floor at a time. This zoning permits more flexibility in operation, especially for tenants requiring extended hours.

More recently, further savings have been made with variable speed drives on fans and pumps.

The result of these changes is shown in Figure 3-6. Fan duration has been assumed at 3000 hrs/yr and pump operation at 4000 hrs/yr.

Future fan savings will be gained from lower air volume to suit still further reduced lighting.

d) *Energy for Water Chilling*

Operating time for chillers depends on whether the building has an economizer ("free cooling") either by having fans that can supply 100% outside air, when required, for cooling or from a plate type heat exchanger on the chilled water loop.

For central HVAC systems the equivalent full load operating time will be approximately 1000 hrs/yr. For compartmented HVAC systems, having a separate fan system for each floor, this will climb to 1800 hrs/yr. If waterside free cooling is added by involving the water tower as a winter chiller, the operating hours may be 1400 hrs/yr.

Chiller energy can take advantage of reductions in lighting and coincident reductions in fan and pump energy.

The results of these and other efficiency improvements are described on Figure 5.

Figure 3-6: IMPACT OF MEASURES ON FAN AND PUMP ENERGY USE & COST

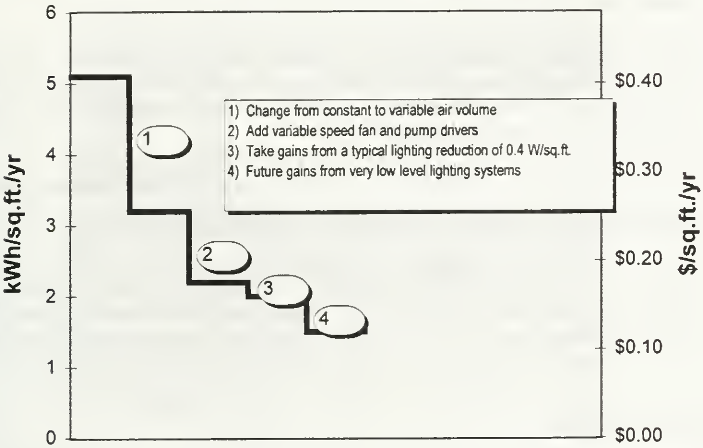
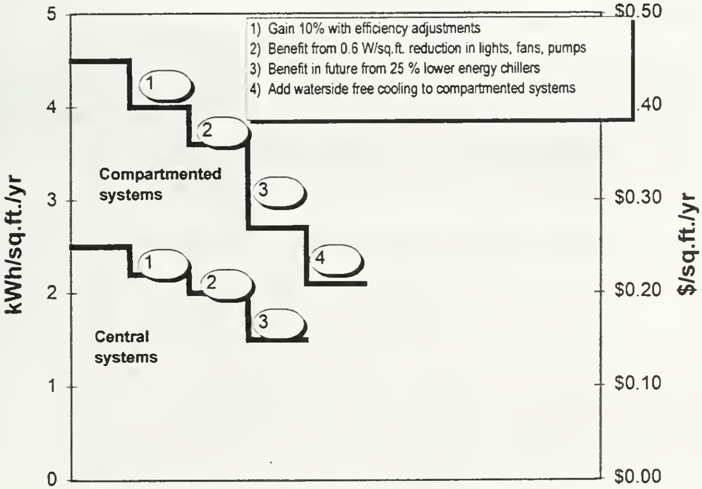


Figure 3-7: IMPACT OF MEASURES ON CHILLER ENERGY USE & COST



e) *Energy for Plug Load*

Receptacle or plug load is mainly a tenant issue in rental buildings. It is averaging about 125 watts/person for computers, copiers and printers. Based on one person per 200 ft^2, this amounts to 0.625 W/ft^2.

Studies in 1992 at Hydro Place found computers operated an average of 54% of the time or 4730 hrs/yr at an average of 0.6 W/ft^2. This high level is slowly being reduced with "Energy Star" equipment. Energy star may soon be improved with a new sleep mode, dropping from 35 to 10 Watts for personal computers.

If office occupants can be trained to shut off their equipment before leaving work, the level of use will drop to less than 2000 hrs/yr with a 58% saving.

Some of this saving will be negated however by smaller office workstations which are falling in area from 100 ft^2 (10 m^2) to 50 ft^2 (5 m^2) with a consequent increase in occupant density. More occupants require more equipment. This will also impact upon cooling and ventilation energy. Building owners and managers should be aware of this trend and the consequent impact on plug load, cooling load, and ventilation requirements.

f) *Energy for Elevators*

For building renewal, elevator upgrades often take precedence over other energy conservation measures for building owners. New elevator drive machinery can be more energy efficient but the simple payback for energy alone is above 25 years. Elevator energy depends on cab speed which, in turn, is related to building height and waiting time. Energy efficient scheduling controls can also improve waiting time and reduce energy.

g) *Energy for Service Hot Water*

Energy can be saved for domestic uses by providing one faucet delivering water at 40°C instead of separate hot and cold faucets. For uses requiring water at higher temperature, local booster heaters can meet this need. Energy can also be saved in new buildings by reducing the length of recirculation lines, and insulating lines and tanks to a greater to levels such as recommended in ASHRAE/IES 90.1.

h) *Building Envelope*

Commercial and industrial buildings have lagged behind residential buildings in terms of thermal efficiency. The envelope of many of these buildings is a shell of metal, glass and concrete with little or no insulation. All these materials are good conductors of heat.

Traditional glass and metal curtain wall construction results in a high rate of air leakage due to the many joints between components. This is compounded by the stack effect in high-rise buildings.

Large areas of glazing result in large cooling loads in the summer and high heating loads in the winter.

Combat these problems with the following measures:

- Insulate walls, roofs and floors
- Reduce window areas where not required
- Add storm windows or insulation to glazed areas
- Insulate large uninsulated doors
- Install automatic door closers, revolving doors and loading dock shelters to minimize the incursion of outside air
- Replace air curtain doors with solid doors
- Add vestibules to high-traffic doors to minimize air leakage and reduce heat loss
- Install plastic strip curtains between areas with different temperature requirements
- Install awnings, window shades or reflective films to reduce cooling loads
- Utilize trees and shrubs as sun shades and windbreaks

Window film can be added to existing buildings with single glazing. Modern window films incorporate low-emissivity (Low-E) capability which improves the heat transmission factor, and greater reflectivity which reduces excessive solar gains. Solar gain must be considered in the context of the geographic location of the buildings, however, as it increases cooling energy use but decreases heating energy use.

3.2 Water Conservation Opportunities

Domestic Water Fixtures

Several different approaches enable plumbing fixtures to be both effective and water-saving:

- Retrofit faucets and shower heads with aerators which add air to the flow stream, resulting in a spray-like flow and reducing water usage.
- Replace the faucets and showerheads with reduced-flow models.
- Install flow reduction disks in showerheads.
- Use metering faucets to deliver a measured quantity of water on demand.
- Use spring loaded faucets which shut off automatically after use.
- Adjust toilet and urinal valves to reduce flow without reducing flushing effectiveness. Flow reduction devices can also be installed.
- Retrofit water closets with individual tanks with a dam or a water-filled plastic container in the tank to conserve a portion of the volume used by each flush.
- Install ultra-low volume toilets and urinals, which are are available in versions with improved bowl designs and flushing procedures. The models with the lowest water use usually incorporate either a siphon action or air or vacuum assistance. Units with field-adjustable valves must be kept properly adjusted to prevent unnecessary water usage.
- Install automatic controls for toilets, urinals, and faucets using a beam of infrared light to control flushing or faucet flow. These devices deliver metered flows, only on demand, preventing running of water at faucets not in use. The controls are designed to prevent activation by passers-by and to reset after use to accommodate the next person. In addition, there is no need for the user to contact an activating device, which may ease use by the handicapped and help prevent the spread of disease.
- Install a pressure-reducing valve when main pressure generally is greater than 80 pounds per square inch (psi). Plumbing systems are designed to perform acceptably at pressures as low as 40. Further conservation could be achieved by installation of a pressure-reducing valve to reduce pressures to 60 psi.

Approximate costs for new fixtures and retrofit alternatives are presented in the following table.

Item	Cost Range
Kitchen faucet	$90-200
Lavatory faucet	$100-135
Lavatory faucet, metering type	$100-165
Faucet aerator	$6-10
Showerhead	$10-20
Toilet, ultra-low volume, floor mount Toilet, ultra-low volume, wall mount	$250-350 $275-375
Urinal tank electronic control	$1,000-1,400
Infrared faucet control	$400
Infrared water closet/urinal control	$370

Water Cooling Systems

Water is commonly used in cooling systems for cooling towers, evaporative coolers, and once-through cooling.

Cooling Towers

Cooling towers are used as the mechanism for rejecting heat from air conditioning systems, and consume a significant quanitity of water. The water which passes through a cooling tower then circulates through a cooling system, warms, and returns to the tower. Evaporation of a portion of the water in the cooling tower provides the cooling of the water. This results in an increase in the concentration of impurities in the circulated water requiring some steps such as water treatment to be taken.

The quality of water circulating through an evaporative cooling system has a significant effect on the overall system efficiency, the degree of maintenance required, and the useful life of system components. Because the water is cooled primarily by evaporation of a portion of the circulating water, the concentration of dissolved solids and other impurities in the water can increase rapidly. Also, appreciable quantities of airborne impurities, such as dust and gases, may enter during operation. Depending on the nature of the impurities, they can cause scaling, corrosion, and/or silt deposits.

To limit the concentrations of impurities, a small percentage of the circulating water is wasted (called blowdown or bleedoff). The number of concentrations thus obtained in the circulating water can be calculated from the equation:

$$No.\ of\ Concentrations = \frac{Evaporation + Drift + Blowdown}{Drift + Blowdown}$$

The entries in this equation may be expressed as quantities or as percentages of the circulating rate. The evaporation loss averages approximately 1% for each 12.5F of cooling range, while drift loss on a mechanical-draft tower is usually less than 0.2% of the circulating rate. Accordingly, for a tower operating with a 12.5F range and using a figure of 0.1% for drift, a blowdown rate of 0.9% of the circulating rate would be required to maintain a level of two concentrations.

In addition to blowdown, evaporative cooling systems are often treated chemically to control scale, inhibit corrosion, restrict biological growth, and control the collection of silt. Scale formation occurs whenever the dissolved solids and gases in the circulating water reach their limit of solubility and precipitate out onto piping, heat transfer surfaces, and other parts of the system. Simple blowdown can often control scale formation, but where this is inadequate, or it is desirable to reduce the rate of blowdown, chemical scale inhibitors can be added to increase the level of concentrations at which precipitation occurs. Typical scale inhibitors include acids, inorganic phosphates, and similar compounds.

Corrosion and scale are controlled by blends of phosphates, phosphonate, molybdate, zinc, silicate, and various polymers. Tolyltriazole or benzotriazole are added to these blends to protect copper and copper alloys from corrosion. Chromates were previously used for corrosion control, but as of January 1990, their use has been banned in cooling tower treatment in comfort cooling systems. *When selecting a treatment product, consult local, provincial, and federal environmental guidelines and requirements.* The phosphate compounds, while nontoxic, tend to promote algae growth; their use, therefore, may be limited in the future.

Algae, slimes, fungi, and other microorganisms grow readily in evaporative cooling systems and can:

- form an insulating coating on heat transfer surfaces
- restrict fluid flow
- promote corrosion, and/or
- attack organic components within the system (such as wood).

The common method of control is to shock treat the system on a periodic basis with a toxic agent such as chlorine or other biocide. Normally, two different biocides are added on an alternating basis to ensure microorganisms do not develop a resistance to any one compound.

During normal cooling tower operation, large quantities of airborne dirt can enter and subsequently settle out as silt deposits. Such deposits can promote corrosion, harbour microorganisms detrimental to the system, and obstruct fluid flow. Silt is normally controlled by adding polymers, which keep the silt in a suspension while it flows through the system. Eventually, it settles in the tower basin where deposits can be more easily removed during periodic maintenance.

In most cases where chemical water treatment is practised, a competent water treatment specialist can be invaluable because system requirements can vary widely.

Once-through Cooling

Many facilities have one or more pieces of equipment cooled by a single-pass flow of water. After passing through and cooling the equipment, the water is discarded. This is prohibited by many municipalities. Equipment which might be cooled by once-through water includes: degreasers, rectifiers, hydraulic equipment, x-ray machines, condensers, and viscosity baths, air conditioners, air compressors, hydraulic presses, welders, and vacuum pumps. Much more efficient water use would involve connecting the equipment to a cooling tower system or using the single-pass effluent for some other use such as for landscape irrigation.

Water for Landscaping

There are a number of ways to conserve water used for landscape irrigation. Proper sprinkler design, installation and maintenance is one way to conserve a significant amount of water. Water can also be saved with good planting practice and proper maintenance. These concepts are also known as "Xeriscape".

- Irrigation systems should be designed to avoid unnecessary sprinklers and blockage of the spray stream by obstacles.
  - Sprinklers should serve only the required irrigation areas and not spray on buildings or non-landscaped areas.
  - The irrigation system should have a timer or moisture sensors to activate the system and watering should be done before sunrise or after sunset to reduce evaporation losses.
  - Turfed areas and planters, trees and shrubs may be watered separately to meet differing needs.

- Proper system maintenance is essential to irrigation water conservation.
  - Sprinkler heads should be inspected regularly, and damaged, worn, or broken heads should be replaced promptly.
  - Sprinkler heads should be cleaned periodically to remove mineral deposits and maintain hydraulic efficiency.
  - The system should be inspected for leaks in pipes, couplings, and faucets and repaired as necessary.
  - Sprinkler timing cycles should be seasonally adjusted to meet varying seasonal demands.

- Plant selection and replacement reduces water usage.
  - Low water use, drought-tolerant plants should be used.
  - Trees and shrubs in planters should be used rather than turf.
  - Planting beds should have a layer of wood, mulch, or rock to help retain water.
  - Low and high water use plants should not be mixed; this will help avoid unnecessary watering of the low water use plants.
  - Higher water use plants can be planted in low areas to intercept runoff and decrease the need for supplemental watering.

- Proper maintenance of turf and gardens conserves irrigation water.
  - Turf should be kept out to the proper height: one and half to two inches for cool season grasses, and three-quarters to an inch for warm season grasses.
  - Dethatching turf increases aeration and infiltration which leads to healthier turf and decreases water consumption.
  - Drought resistance is assisted by decreasing nitrogen fertilizers and increasing potassium levels.
  - Weeds will compete with the desired plants for water and should be removed regularly.

3.3 Waste Management Opportunities

The following steps should be taken to identify waste reduction and recycling opportunities:

- Determine which materials comprise the largest percentage of the waste stream
- Assess whether there is any specific material which costs more to dispose than others
- Identify those materials which produce maximum diversion for minimum costs
- Assess whether some materials can be eliminated altogether from entering the waste stream
- Assess the ease with which materials can be source separated; some materials are better collected mixed with other recyclable materials
- Identify any local legislation or by-laws governing disposal and recycling of materials
- Assess the availability of space to collect and store the recyclables
- Assess the complexity of different recycling approaches and the willingness of tenants and employees to participate in the different systems
- Ensure that the system employed for collection waste is easily distinguished from the recycling system (i.e., use different coloured bags and/or bins, eliminate or reduce the use of garbage bins to recycling bins, locate recycling bins in high generation areas)
- Use signs/labels appropriately to encourage accurate participation in the program (the more complex the program, the greater reliance on signs/labels)
- In locations of heavy public traffic (e.g., cafeteria) it is a good idea to locate garbage containers along with recycling containers to reduce contamination by providing convenient opportunities for tenants to correctly source separate.

a) Greening the Procurement Process

There are a number of opportunities for waste reduction through responsible and informed procurement practices.

Basic tasks required to move towards greener procurement activities:

- review of purchasing records/files with those who actually do the purchasing;
- conduct visual inspection of supply cupboards and storage areas;
- undertake discussions with service contractors to estimate types and quantities of materials and products procured for service contracts (e.g., cleaning and building contractors).

The following steps should be taken to evaluate current procurement practices and identify areas for improvement:

- Assess the purchases made for the building over which each company has control
- Determine whether the product or package being considered can be locally recycled
- Identify the top 20% of products purchased and focus on these first
- Identify those products that can be eliminated, reduced in number purchased
- Determine if the use of refillable, reusable products can be increased
- Determine if non-refillable products can be replaced with recyclable
- Determine whether some products or packaging can contain more recycled content
- Assess the difference in cost to purchase greener products
- Identify other tenants which use the same product and determine if larger purchases in a cooperative manner could save costs

b) Contract Arrangements

The most common way to realize savings in waste disposal is to reduce the amount of waste that must be collected (and therefore paid for). Increased recycling can often decrease costs, depending on market conditions.

An understanding of how waste disposal services operate will help when negotiating for lower costs:

- ***A monthly flat fee*** may be charged each month, regardless of the amount of garbage generated. The frequency with this service is generally fixed.
- ***A pay per lift system*** charges a fee for each container that is emptied. The fee is the same if the container is full or only one-third full. Additionally, there may be a rental fee for the container. The frequency of collection may be fixed or flexible.
- In a ***pay/cubic yard or tonne system***, a specified fee is charged for each tonne or cubic yard of material collected. In some instances, a "lift" fee may also be charged.

There is a great deal of opportunity for office buildings to reduce operation costs by re-negotiating waste management contracts or establishing new contracts with built-in features specific to garbage collection and recycling. For example, office buildings that use on-site compactors should have a feature that indicates when the compactor is three-quarters full so that maintenance staff can phone the hauler to collect the waste - this reduces costs. Some haulers will try to arrange regular scheduled pick-ups regardless whether the bin is full– companies are then charged per pickup as well as by volume or weight of the container.

Examination of the waste audit results may reveal opportunities to save money by monitoring and renegotiating the waste hauling arrangements.

The following steps should be carried out to determine if the best contractual arrangements are in place for waste management:

- Determine the average fullness of the garbage bin during collection by the hauler
- Identify the frequency of collection and the need for the frequency, especially after the introduction or enhancement of a recycling program
- Consider the benefits (financial and operational) of having garbage collection and recycling provided by the same company
- Determine the quality and volume of the recyclable materials and shop around for the best deal (some companies will pay for the recyclables or offer other incentives in order to secure you as a customer)
- Assess the ability of the waste hauler to provide weight-based information on the invoices (this should be seen as a priority)
- Determine if the selected recycling company provides value added services (i.e., waste audit, promotional materials, signs/labels, bins)
- Determine the flexibility in the contract to modify collection arrangements to meet changes in the waste collection and/or recycling program, such as adding on new materials over time and/or reducing collection frequencies for waste
- Find out what the recycling company does with the recyclable materials and how they are used by the end user (some uses may be more environmentally preferable than others)
- Determine the arrangements offered by recycling companies to supply recycling containers (i.e., on a purchase, rental, or free basis)
- Determine the level of contamination of the recyclable stream permitted and the repercussions (e.g., penalties for high contamination levels)

c) Composting

The following steps should be taken to assess the feasibility of implementing a composting program in an office building:

- Determine the make-up of tenants in the building
- Identify whether or not there is a cafeteria or food service establishment in the building
- Determine to what extent the organics consist of coffee grounds (through visual or detailed waste audit) because this will impact on the diversion opportunities
- Identify current costs for waste collection and disposal per unit (i.e., tonne, per bin)
- Assess the availability of space to set up a composting system on the property
- Determine the number of employees that would need to be educated and trained to separate organics
- Determine willingness of employees to participate and tenant concerns about odour, nuisances, etc.
- Assess the complexity of the collection system required
- Identify the availability of off-site organic programs
- Assess the availability of storage space for source separation and frequency of collection required for off-site program to eliminate odour concerns

d) Tenant Programs

Depending on the system and the cooperation of the staff and tenants, tenants can be encouraged to recycle only the recyclable paper waste (thus increasing the savings) or a recycling company can be hired to do the work (which will cost a bit more money). If the building is large enough to produce good quality paper (i.e., computer paper) on a consistent basis, the property manager is in a better position to negotiate the terms of collection and can generate revenues for the paper.

4. The Monitoring Phase

Ongoing monitoring of a building's energy and water use is essential to the long-term success of a resource conservation program. Historical energy and water use data and waste types and quantities obtained for the initial audit can serve as a base for comparison. The building's total energy, water and waste per square metre (or square foot) can then be monitored monthly and calculated annually and compared with the base.

Continued monitoring will serve several purposes:

- It will establish benchmarks specific to the building for energy water and waste
- It will provide a basis for comparing current building operations with past performance, and build a picture of the characteristics of the resource use and waste generation of the building
- It will identify increased energy or water use that may occur if maintenance and/or operating problems arise. These problems can then be found and corrected
- It will identify increased energy or water costs, and permit an analysis to determine the relative impact of utility prices and operating changes
- It will permit building management to identify tenants/occupants who have excessive energy and/or water use
- It will identify changes in the waste stream, and the tenants/occupants who are causing those changes
- It will track the cost of waste haulage and track any changes in the price structure
- It will demonstrate the energy and water consumption savings achieved by the program. This will build confidence in the program so that it can be maintained and expanded over the years.
- It will help to evaluate the effects of specific energy, water and waste management measures and thus demonstrate their cost effectiveness.

The procedures for analysing utility and waste haulage invoices described in Chapter 3 – "The Audit Phase" should be followed monthly.

- List the information in the format described, using either manual forms or a computer spreadsheet.
- Plot new points on the graphs each month, and look for usage patterns.
- Analyse those patterns to determine the reasons for changes in use or cost.
- Use the graphical presentation in your management reports to make the point that resource conservation and waste management is good business and good for the environment.

A Resource Accounting System will help to normalize data for weather and other variables, check utility billing for proper application of rates, and will keep a detailed tabular and graphical record of consumption patterns.

What is Resource Accounting?

Resource Accounting is defined as the systematic tracking and analysis of energy and water costs and consumption in order to better manage and control their use in buildings. The information gathered through monitoring and utility bills is used to report on the expenditures for energy and water, or the progress of a Resource Management Program. It involves determining where energy and water are used, how much and why. When the factors that affect their use are understood then appropriate adjustments can be made to consumption figures. These adjustments will allow the Resource Manager to see how well the building is performing compared to other buildings or to previous years of operation.

Many factors affect building energy use. These include:

- ***Weather conditions at the building site***

- ***Design, quality and condition of the building envelope:***
  - insulation value of walls and roof,
  - number and size of windows,
  - quality and type of windows,
  - air leakage around windows, doors and other openings.

- ***Building mechanical systems:***
  - heating, ventilating and air conditioning systems and their operation,
  - process activities inside the building such as lighting, hot water and appliances,
  - maintenance of building equipment and systems,
  - efficiency of systems and components.

- ***Patterns of building occupancy and use.***

Resource Accounting involves a comparison of consumption against a standard or against a previous year. When comparing consumption, it is important to adjust for any changes in building variables.

Two key principles are applied:

- Adjustments due to an external factor (such as weather) should only be made to that portion of consumption affected by that external factor.

- The effects of a variable must be significant enough to warrant adjustment in the Resource Accounting method (weather is a significant variable for month to month comparison).

Features of an Energy Accounting System

In order to reliably account for energy use and to allow proper comparisons, the following features are desirable:

- ***Cost and Consumption Tracking:*** Systems should track both energy cost and consumption on a monthly and year to date basis. Often, year to date values are more indicative of true performance than monthly values. Alternately, the system can calculate the costs based upon the utility rate schedule. This reduces input data quantities while providing check figures with which to identify inconsistencies in utility billing.

- ***Demand Tracking:*** In certain locations, the demand charges from the electrical utility are the major portion of the total electrical bill. It is advisable to track demand and demand costs in those locations where the demand cost becomes significant.

- ***Baseline Comparison:*** The baseline serves as a "yardstick" with which to measure current performance.

- ***Normalization:*** The system should normalize (adjust) for differing numbers of days in the billing period before calculating performance percentages to prevent billing period variances from introducing meaningless fluctuations in reports. It should make adjustments for weather variations while recognizing that not all energy consumption is weather related. In addition, adjustments should be made for changes in building use, occupancy or size.

- ***Calculate Energy Use Index:*** The system should be able to convert all energy used in each building to a common unit basis, (MJ/m^2 or $ekWh/ft^2$), and then calculate monthly and year to date values to rank building efficiency. As many new building standards are based upon unit area energy consumption, it is important to see how your buildings compare with others. You may also want to calculate energy use per person or per unit of production depending upon specific needs.

- ***Use a Tiered Reporting System:*** Each Manager needs only their data and their performance percentages. A one page building summary is usually best. Likewise, senior management need only the bottom line – a concise executive summary report. Should detailed information be required, it should be available.

The Impact of Utility Rate Structures

The applicable rate structure for any given building must be carefully considered when quantifying savings for that building; differing structures impact billing costs and thus actual savings realized through resource conservation measures. Further, the end tier at which the building is operating, and whether this tier changes after the retrofit, must be considered.

Electric Utility Rates

Electric rates determine the cost to the customer of units of electrical use. Most rate structures consist of a demand charge and a tiered energy consumption charge. Rate structures are set by the utility. Different utilities across the province impose differing rate structures from one another. Any given utility then sets different rate structures by customer class.

The type of rate offered to most office buildings is referred to as a *General Service Rate.* The General Service Rate typically applies to customers whose peak demand is either between 50 and 1,000 kW (e.g. Toronto), or 50 and 5,000 kW (e.g. Hamilton).

The General Service Rate typically consists of one of two types of declining block structures.

- ***Type A*** is a declining block structure with the size of the tiers defined by the metered consumption. A higher rate is applied to the first specified block of consumption, a lower rate to the next specified block of consumption, and so on. Type A rate typically has a demand charge for the billing period for the peak demand exceeding 50 kW.

- ***Type B*** is a declining block structure with the tiers defined by a specified number of hours of use which is then applied to the peak demand. That is, the higher rates of the initial tiers are applied to consumption which is dependant on the peak demand of the period. The higher the peak demand, the greater the size of the initial tiers, or the greater the amount of consumption charged at the higher rates of the initial tiers. The effect of the peak demand on the overall monthly bill is actually greater than the cost/kW.

The difference between Type A and Type B can have a significant impact on the actual billing costs and, consequently, on savings realized through energy-savings retrofits.

Utilities generally change the rate for customers whose peak demand exceeds the limit of the General Service Rate to a *Time-Of-Use Rate*. Time-Of-Use Rates define winter and summer months, peak, shoulder and off-peak hours. Typically, there is a demand charge and a declining tiered consumption charge, with the tiers defined by specified consumption blocks.

Customers whose peak demand is below 50 kW are offered another type of rate, referred to as a residential rate.

The following sections define the different types of rate structures and, through use of examples, illustrate the effect that differing rate structures have on billing and on resource conservation savings.

Typical Rate Structures

There are two types of General Service Class declining tier rate structures. Examples of each type and of a Time-Of-Use Rate are found in Table 4-1

The following lists the type of General Service Rate structure for some municipalities across Ontario

Rate Structure	Location		Rate Structure	Location
Type A	North York Etobicoke Oakville Richmond Hill Pickering London North Bay Ottawa	York Brampton Mississauga Markham Sudbury Windsor Thunder Bay	**Type B**	Toronto Scarborough Hamilton

Effect of Rate Structure on Billing Costs

The following example illustrates the significant impact the rate structure has on actual billing costs. It also illustrates the importance of maintaining a low peak demand, particularly under certain rate structures.

Example 1

Over a 30 day billing period in a winter month, Building *X* reaches a peak demand of 1,500 kW each weekday (20 days), but rises to 1,800 kW for one weekday due to ramp heaters being mistakenly turned on. Total consumption for the period was measured at 615,600 kWh. Operation was 14 hours/weekday, between the hours of 7:00 a.m to 9:00 p.m. The period consisted of 9 weekend days and 21 weekdays.

The typical rate structures from Table 4-1 are used to calculate the monthly electrical bill for this building as shown on Figure 4-1.

This example illustrates the significant effect the rate structure can have on the actual monthly billing cost. Of particular note is the effect that peak demand has on the actual costs under the Type B rate structure. The one day of peak in the period resulted in a cost which was 17% higher when the bill was calculated under Type B as compared to Type A. As demand carries the highest unit cost in all rate structures, it is always important to attempt to reduce the monthly peak demands. This is of particular importance, however, under a rate structure where the portion of the consumption charged at the higher rates of the initial tiers is dependant upon the peak demand. In effect, the penalty for higher peak demand is greater under the Type B structure than under the Type A structure.

Table 4-1
Electric Utility Rates

GENERAL SERVICE RATE: TYPE A (example:Sarnia)		
Demand Charge	First 50 kW @	$ 0.00 /kW
	Balance kW @	$ 5.75 /kW
Energy Charge	First 250 kWh @	$ 0.1124 /kWh
	Next 12,250 kWh @	$ 0.0814 /kWh
	Next 1,474,000 kWh @	$ 0.0584 /kWh
	Balance kWh @	$ 0.0354 /kWh
Note: energy tiers are defined by specified consumption blocks		

GENERAL SERVICE RATE: TYPE B (example: Hamilton)		
Demand Charge	All kW @	$ 5.50 /kW
Energy Charge	First 100 hours @	$ 0.0995 /kWh
	Second 100 hours @	$ 0.0746 /kWh
	Balance @	$ 0.0498 /kWh
Note: energy tiers are defined by hours of use applied to the peak demand		

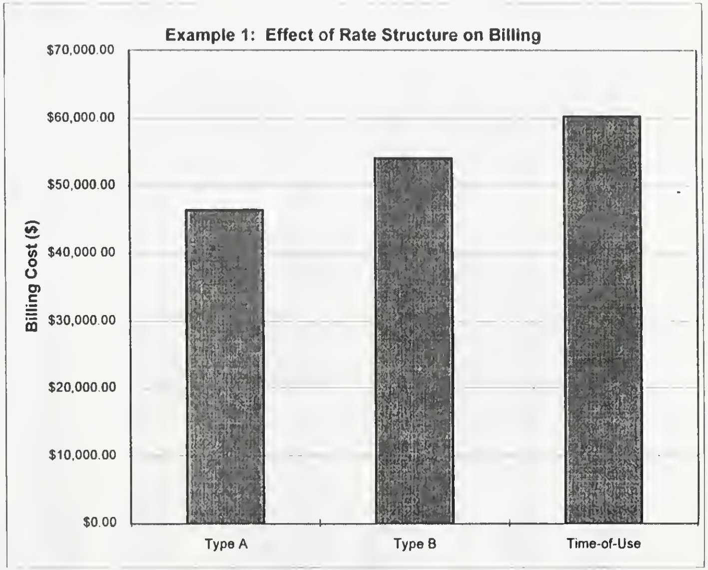
Time-of-Use Rate (example: Toronto)			
		winter	summer
Demand Charge	First 5,000 kW	$ 9.68 /kW	$ 7.91 /kW
	Balance kW	$ 12.49 /kW	$ 9.78 /kW
Energy Charge (peak/shoulder)	First 195,000 kWh @	$ 0.0913 /kWh	$ 0.0778 /kWh
	Next 850,000 kWh @	$ 0.0737 /kWh	$ 0.0615 /kWh
	Balance kWh @	$ 0.0637 /kWh	$ 0.0547 /kWh
Energy Charge (off-peak)	All kWh @	$ 0.0385 /kWh	$ 0.0280 /kWh
Peak: Monday-Friday 9:00 a.m. - 8:00 p.m. Shoulder: Monday-Friday 7:00 a.m. - 9:00 p.m. ; 8:00 p.m. - 11:00 p.m. Off-peak: Monday-Friday 11:00 p.m. - 7:00 a.m. ; Weekends and Statutory Holidays 24 hours			

Figure 4-1: Example 1

Type A Declining Tier Rate Structure:			
Peak Demand	1800 kW		
Consumption:	615,600 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$10,062.50
Energy Charge:	First 250 kWh @	$ 0.1124 /kWh	$28.10
	Next 12,250 kWh @	$ 0.0814 /kWh	$997.15
	Next 603,100 kWh @	$ 0.0584 /kWh	$35,221.04
Total Bill:	**$46,308.79**		

Type B Declining Tier Rate Structure:			
Peak Demand	1800 kW		
Consumption:	615,600 kWh		
Demand Charge:	All kW @	$ 5.50 /kW	$9,900.00
Energy Charge:	First 100 hours @	$ 0.0995 /kWh	$17,910.00
	Second 100 hours @	$ 0.0746 /kWh	$13,428.00
	Next 255,600 kWh @	$ 0.0498 /kWh	$12,728.88
Total Bill:	**$53,966.88**		

Time-of-Use Rate Structure			
Peak Demand:	1800 kW		
Total Consumption:	615,600 kWh		
Month:	Winter		
On-Peak Consumption	445,200 kWh		
Off-Peak Consumption	170,400 kWh		
Demand Charge:	1800 kW	$ 9.68 /kW	$17,424.00
Energy Charge (peak/shoulder)	First 195,000 kWh @	$ 0.0913 /kWh	$17,803.50
	Next 250,200 kWh @	$ 0.0737 /kWh	$18,439.74
Energy Charge (off-peak)	170,400 kWh	$ 0.0385 /kWh	$6,560.40
Total Bill:	**$60,227.64**		



A few utilities in Ontario may also have ratchet rate clauses in their structure, which can result in very large penalties for increased or spiked peak demand. Ratchet clauses state that the demand charges will be no less than a certain percentage (often 85-95%) of the peak demand set in the previous 11 months. This means, for the building in Example 1, the billed peak demand would be roughly 1,600 kW for the 11 months after the spike occurred, even if the building only reached its normal 1,500 kW each day for those 11 months.

Effect of Rate Structure on Savings Realized Through Energy Savings Retrofits

Energy retrofits will have different savings depending on the utility rate structure. Thus, rate structures must be carefully considered when calculating potential energy savings due to the implementation of energy efficient measures.

The following example examines the savings realized from a lighting retrofit done to the building of Example 1 and the impact of a demand spike in the billing period on the expected savings.

Example 2

- Consider the building of Example 1, same billing period, same operating hours. The building reaches a daily peak demand of 1,500 kW. Based on the operation outlined in Example 1 (regular operation, without the demand peak spike), the total consumption for the period (pre-retrofit) is 611,400 kWh.

- Now assume that a lighting retrofit is implemented in this building, creating a demand reduction of 300 kW. Regular daily peak demand of 1,500 kW is expected to drop to 1,200 kW daily. *If* the normal (expected) peak of 1,200 kW is reached daily throughout the billing period (no spike), one would expect the following savings to be realized from the retrofit as shown in Figure 4-2 (assume all other operation parameters and rate structures are as described in Example 1).

- Consider now, for a reason unrelated to lighting (eg. Ramp heaters on accidentally), the demand of the retrofitted building rose from its new reduced daily peak of 1,200 kW to 1,500 kW (added load of 300 kW) on only one day of the billing period, as in Example 1. This is illustrated in Figure 4-3.

- Although the building received a lighting retrofit and the 'regular' peak load was reduced by 300 kW for 29 of the 30 days in the billing period, the expected savings for the entire period were substantially reduced by a spike in the demand on only one day of the period. Notice that the penalty for the demand peak is higher under rate structure Type B where the peak demand sets the size of the energy tiers.

Figure 4-2: Example 2

Type A Declining Tier Rate Structure:			
PRE-RETROFIT			
Peak Demand	1500 kW		
Consumption:	611,400 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$8,337.50
Energy Charge:	First 250 kWh @	$ 0.1124 /kWh	$28.10
	Next 12,250 kWh @	$ 0.0814 /kWh	$997.15
	Next 598,900 kWh @	$ 0.0584 /kWh	$34,975.76
Total Bill:	**$44,338.51**		

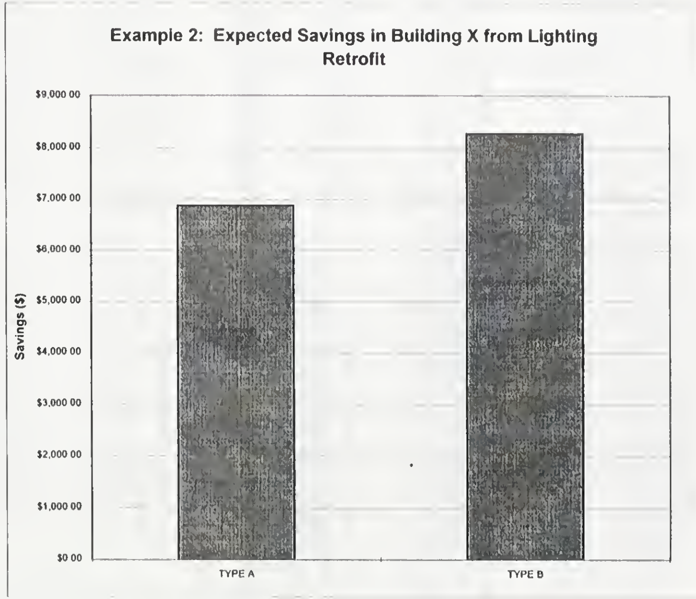
POST-RETROFIT			
Peak Demand	1200 kW		
Consumption:	523,200 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$6,612.50
Energy Charge:	First 250 kWh @	$ 0.11 /kW	$28.10
	Next 12,250 kWh @	$ 0.08 /kW	$997.15
	Next 510,700 kWh @	$ 0.08 /kW	$29,824.88
Total Bill:	**$37,462.63**		

TOTAL SAVINGS TYPE A:	$6,875.88

Type B Declining Tier Rate Structure:			
PRE-RETROFIT			
Peak Demand	1500 kW		
Consumption:	611,400 kWh		
Demand Charge:	All kW @	$ 5.50 /kW	$8,250.00
Energy Charge:	First 100 hours @	$ 0.0995 /kWh	$14,925.00
	Second 100 hours @	$ 0.0746 /kWh	$11,190.00
	Next 311,400 kWh @	$ 0.0498 /kWh	$15,507.72
Total Bill:	**$49,872.72**		

POST-RETROFIT			
Peak Demand	1200 kW		
Consumption:	523,200 kWh		
Demand Charge:	All kW @	$ 5.50 /kW	$6,600.00
Energy Charge:	First 100 hours @	$ 0.0995 /kWh	$11,940.00
	Second 100 hours @	$ 0.0746 /kWh	$8,952.00
	Next 283,200 kWh @	$ 0.0498 /kWh	$14,103.36
Total Bill:	**$41,595.36**		

TOTAL SAVINGS TYPE B:	$8,277.36



Load Shedding

The significant effect of demand on billing costs suggests there is value in considering load shedding practices. Load shedding means modifying the operation of a building to ensure the demand does not exceed a certain peak. Some examples of load shedding practices include shutting down portions of elevator banks, shutting off large area lighting over lunch periods (coinciding with the load from cafeterias) and shutting down large circulating fans for short periods. Often load shedding results in a small compromise of occupant comfort and provision of services. Some loads can be shifted to non-peak periods through rescheduling without affecting occupant comfort. Strategic building automation practices using sensors to detect occupancy, air quality etc. can often reduce peak loads through better control of ventilation, temperature conditions and lighting schedules. "Intelligent" systems can pre-determine peak requirements and use off-peak energy to prepare the space prior to the peak, thereby reducing overall demand at the peak.

Effect of Moving Tiers Within a Given Rate Structure

Another possible impact on expected energy savings involves the tier at which the building sits within a given rate structure. If the position on the tier pre and post-retrofit are different, savings may not be as expected. That is, two buildings of differing use volume and receiving the *same* energy retrofit may show different actual savings. The following example of a smaller building illustrates this effect using the Type A tiered rate structure.

Example 3

Consider two buildings, Building *A* and Building *B*. A lighting retrofit has been implemented in both buildings which has decreased the electrical load by 20 kW in each building. Both buildings operate for the same number of hours per day and both are on the same Type A declining tier rate structure. However, Building B has a higher overall monthly peak demand than Building A due to other loads in the building. This is illustrated in Figure 4-4.

Although both Building A and Building B had the same lighting retrofit and operated for the same hours, the actual savings realized were higher in Building A than Building B by 15%. This is because all consumption savings realized were at the unit rate of $0.0814/kWh for Building A, whereas all consumption savings realized for Building B were at the lower unit rate of $0.0584/kWh.

Another consideration for the declining tier structure is that of demand savings. A 20 kW load decrease for a building which was only operating at 60 kW prior to the retrofit will only result in an actual dollar savings for demand corresponding to 10 kW. This is because the first 50 kW is free for most rates. Another consideration, similar to that presented in the above example, might be for a change in consumption tier. That is, for a given building, if the energy saving measure results in the billing moving up a tier, the total energy savings will consist of some units at a lower tier unit rate and some at a higher tier unit rate. As you progress up the tiers, the savings are at a higher value per kWh.

When considering the effects of energy savings measures, close attention should be made to consumption, demand and rate structure.

Figure 4-3: Example 3 with Demand Spike

Type A Declining Tier Rate Structure:

PRE-RETROFIT			
Peak Demand	1500 kW		
Consumption:	611,400 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$8,337.50
Energy Charge:	First 250 kWh @	$ 0.1124 /kWh	$28.10
	Next 12,250 kWh @	$ 0.0814 /kWh	$997.15
	Next 598,900 kWh @	$ 0.0584 /kWh	$34,975.76
Total Bill:	**$44,338.51**		

POST-RETROFIT (with demand spike of 300 kw extra)			
Peak Demand	1500 kW		
Consumption:	527,400 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$8,337.50
Energy Charge:	First 250 kWh @	$ 0.11 /kW	$28.10
	Next 12,250 kWh @	$ 0.08 /kW	$997.15
	Next 514,900 kWh @	$ 0.06 /kW	$30,070.16
Total Bill:	**$39,432.91**		

TOTAL SAVINGS TYPE A:	$4,905.60

Type B Declining Tier Rate Structure:

PRE-RETROFIT			
Peak Demand	1500 kW		
Consumption:	611,400 kWh		
Demand Charge:	All kW @	$ 5.50 /kW	$8,250.00
Energy Charge:	First 100 hours @	$ 0.0995 /kWh	$14,925.00
	Second 100 hours @	$ 0.0746 /kWh	$11,190.00
	Next 311,400 kWh @	$ 0.0498 /kWh	$15,507.72
Total Bill:	**$49,872.72**		

POST-RETROFIT			
Peak Demand	1500 kW		
Consumption:	527,400 kWh		
Demand Charge:	All kW @	$ 5.50 /kW	$8,250.00
Energy Charge:	First 100 hours @	$ 0.0995 /kWh	$14,925.00
	Second 100 hours @	$ 0.0746 /kWh	$11,190.00
	Next 227,400 kWh @	$ 0.0498 /kWh	$11,324.52
Total Bill:	**$45,689.52**		

TOTAL SAVINGS TYPE B:	$4,183.20

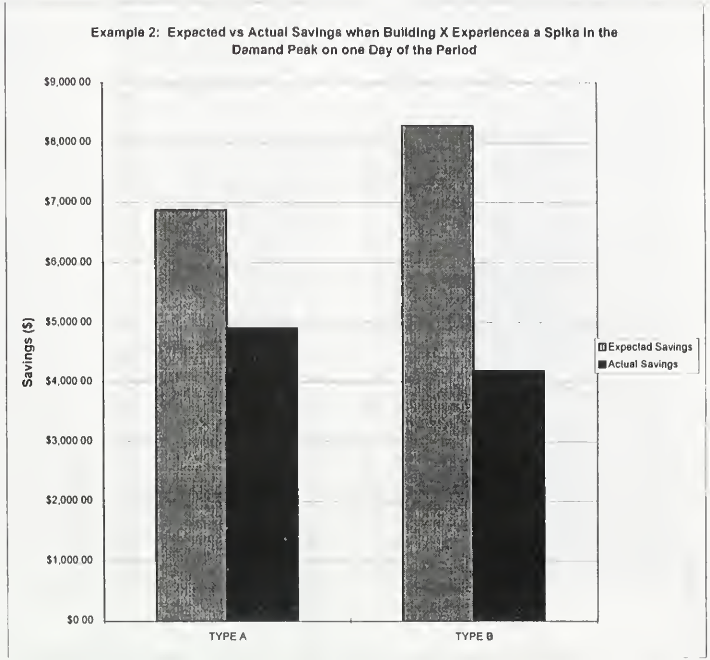


Figure 4-4: Example 3

Building A

Pre-Retrofit			
Peak Demand	70 kW		
Consumption	12,250 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$115.00
Energy Charge:	First 250 kWh @	$ 0.1124 /kWh	$28.10
	Last 12,000 kWh	$ 0.0814 /kWh	$976.80
Total Bill:	**$1,119.90**		

POST-RETROFIT			
Peak Demand	50 kW		
Consumption:	8,750 kWh		
Demand Charge:	Balance kW @	$ 0.00 /kW	$0.00
	First 250 kWh @	$ 5.75 /kW	$0.00
Energy Charge:	First 250 kWh @	$ 0.1124 /kWh	$28.10
	Last 8,500 kWh	$ 0.0814 /kWh	$691.90
Total Bill:	**$720.00**		
TOTAL SAVINGS BUILDING A:	**$399.90**		

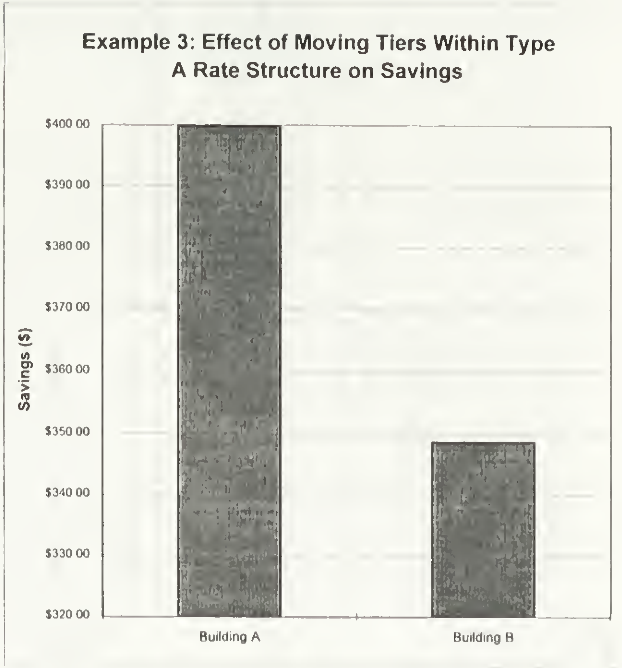
Note: All consumption savings were realized in the 2nd tier at a rate of $0.0814/kWh

Building B

Pre-Retrofit			
Peak Demand	110 kW		
Consumption	22,000 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$345.00
Energy Charge:	First 250 kWh @	$ 0.1124 /kWh	$28.10
	Next 12,250 kWh @	$ 0.0814 /kWh	$997.15
	Last 9,500 kWh	$ 0.0584 /kWh	$554.80
Total Bill:	**$1,925.05**		

POST-RETROFIT			
Peak Demand	90 kW		
Consumption:	18,000 kWh		
Demand Charge:	First 50 kW @	$ 0.00 /kW	$0.00
	Balance kW @	$ 5.75 /kW	$230.00
Energy Charge:	First 250 kWh @	$ 0.1124 /kWh	$28.10
	Next 12,250 kWh @	$ 0.0814 /kWh	$997.15
	Last 5,500 kWh	$ 0.0584 /kWh	$321.20
Total Bill:	**$1,576.45**		
TOTAL SAVINGS BUILDING A:	**$348.60**		

Note: All consumption savings were realized in the 3rd tier at a rate of $0.0584/kWh



Power Factor

Power Factor is a function of the type of electrical load in the building, and is the ratio of the Real Power (measured in kilowatts or kW) divided by the Apparent Power (measured in kilovolt-amperes or kVA). Apparent Power is comprised of Real Power, which is the power required to do work, and Reactive Power, which does no work but which is still necessary to allow some equipment to operate. When the Power Factor is significantly below 100%, there is considerable current which does no work flowing through the conductors, transformers and switchgear which requires them to be sized to handle that current. This additional current is not recovered in the charge for energy or kW. As a result, many utilities charge for a Power Factor less than 90%.

The charge for power factor is usually established by comparing the Real Power (kW) for the billing period with 90% of the Apparent Power (kVA), and using the larger figure for the demand. The additional charge, or penalty, for Power Factor therefore is applied only when the Power Factor is less than 90%.

Since the cause of low power factor in office buildings is inductive loads such as motors and fluorescent lamp ballasts, it can be corrected by installing capacitors at the incoming service panel.

Deregulation in the Electricity Sector

Ontario will be introducing deregulation in the supply of electricity by the year 2000. This will mean that building owners and managers can purchase their electricity requirements from a large variety of suppliers on a competitive basis. This power will continue to be transported by Ontario Hydro to the local utility, and distributed by the local utility to the end-user. The costs for transmission and distribution will be regulated, while the cost for electricity will be negotiable.

It is widely anticipated that power vendors will offer a package of energy services to building owners. These may include energy conservation , power quality, bill review and consolidation, to name a few. Building owners and managers will need to stay abreast of developments to remain competitive in their electricity purchases. Organizations such as BOMA are already offering assistance in this regard.

Gas Rate Structure

Natural may be purchased from a utility or from a separate supplier. Purchases from a utility are made on a System Gas basis. Purchases from a separate supplier are made on a Direct Purchase basis. Each utility in Ontario offers differing rates depending on the customer class. Examples of these are General Service Rates, Industrial and Commercial Contract, Interruptible Industrial and Commercial Contract, Seasonal Industrial and Commercial Contract, Small and Large Wholesale Service Rates, etc. Most utilities offer office buildings a General Service Rate which may include a different rate for summer and winter.

Most gas rate structures consist of a monthly fixed Customer Charge, a Gas Commodity or Supply Charge, one or more Transportation Charges, and a tiered Delivery Charge.. When arrangements are made to purchase gas from a company other than the utility, the Gas Commodity or Supply Charge is the only component which can be negotiated. A Monthly Direct Purchase Administration Charge may also be applied by the gas utility when the building makes a Direct Purchase of their natural gas.

A typical rate structure for Toronto is provided in Figure 4-5.

As in the tiered rate structures for electricity rates, it is important to consider at what tier energy savings will be realized when calculating the value of energy savings associated with a given energy savings measure. If progression is made up the tiers after the retrofit, savings will be higher than if the post-retrofit building remains at the same tier.

Water Rate Structure

Water rates are set by the utilities and vary across the province.

There are four types of rate structures offered by the utilities in Ontario:
- flat rate
- declining block rate
- constant rate
- increasing block rate

Most rates impose a minimum usage charge and may have different unit costs for summer and winter seasons. Many rates also have charges for sewage and sewage collection. Some also have service charges and some rates are dependent on meter size.

The majority of commercial buildings in Ontario are offered either the flat rate (e.g. Toronto) or the declining block rate. The flat rate structure consists of a fixed charge, regardless of the volume consumed. The declining block rate structure consists of blocks (or tiers) of set volumes, where the cost per unit declines for each successive block (e.g. as consumption increases moving through the blocks, cost per unit decreases). Often, the initial block represents a minimum bill charge and includes a set volume of water. This initial block size and that of subsequent blocks varies by utility. For this declining rate structure, it is important to consider at what tier energy savings will be realized when calculating the value of energy savings associated with a given energy savings measure. If progression is made up the tiers after the retrofit, savings will be higher than if the post-retrofit building remains in the same tier.

The constant rate structure is a volume-base structure in which the consumer is charged a fixed price per unit of water consumed. That is, the billing cost increases uniformly with consumption.

The increasing block of rate structure is least commonly offered by utilities in Ontario. This structure is similar to the declining block rate structure, except the cost per unit increases as consumption increases through successive blocks of set volumes consumed. It is important to note the impact this rate structure has on energy savings realized through conservation measures. If progression is made up the tiers after the retrofit, savings will be lower than if the post-retrofit building remains at the same tier. The highest savings are realized on the last consumption block.

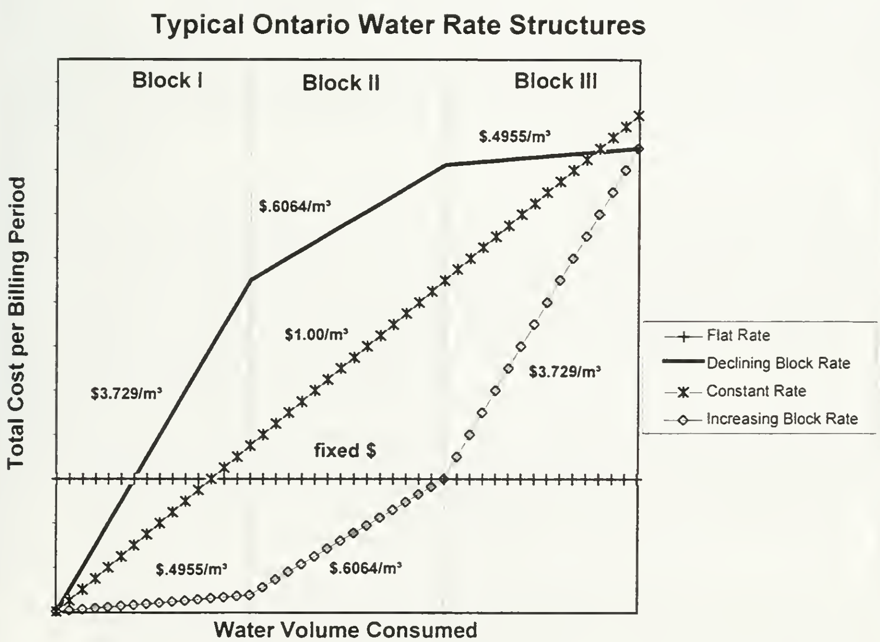
The four water rate schedules are illustrated in Figure 4-5.

Figure 4-5: Natural Gas and Water Rates

NATURAL GAS RATE

General Service Gas Rate: System Gas Basis		
	December - March	April - November
Monthly Customer Charge	$14.00	$14.00
Delivery Charge		
For the first 30 m³ per month	13.5456 cents/m³	10.6210 cents/m³
For the next 55 m³ per month	13.0237 cents/m³	10.0991 cents/m³
For the next 1315 m³ per month	12.4497 cents/m³	9.5251 cents/m³
For the next 1400 m³ per month	11.8255 cents/m³	8.9009 cents/m³
For the next 2800 m³ per month	11.2014 cents/m³	8.2768 cents/m³
For the next 5600 m³ per month	10.2633 cents/m³	7.3387 cents/m³
Gas Supply Charge	7.2658 cents/m³	7.2658 cents/m³

Adjustments to General Service Rate for Direct Purchase		
	December - March	April - November
All charges as above, plus:		
Direct Purchase Gas Cost	(negotiated with supplier)	
Gas Supply Charge Credit	7.2658 cents/m³	7.2658 cents/m³
Transportation Service Credit	3.1943 cents/m³	3.1943 cents/m³
Monthly Direct Purchase Administration Charge	$50.00	$50.00



5. Environmental Issues

There are four main environmental considerations for office building managers:

- Asbestos
- Ozone-depleting substances (CFCs and Halons),
- Polychlorinated biphenyl (PCBs)
- Fluorescent lamp disposal.

Since the arena for environmental regulatory change is very active, the proper authorities should always be contacted for current information. In all cases, if the issue is pertinent to your building, the development of a plan of action with the advice of specialists is highly recommended.

Asbestos

Asbestos is a generic term given to six types of incombustible and separable hydrated mineral silicates that occur naturally. Only three –chrysotile, amosite, and crocidolite have been widely used commercially. Chrysotile, or white asbestos, accounts for more than 98% of the world's asbestos use. The other two types may be called, in common parlance, brown and blue asbestos, respectively. It was chrysotile asbestos that was used as lagging material to provide fire resistance and acoustic insulation on pipes and boilers, in buildings constructed prior to 1976. These applications generally used friable material – when dry, the material can be crumbled or powdered by hand pressure. Friable, sprayed-on fire proofing can be found on beams, columns, trusses, joists, and on ceilings as a decorative finish or acoustical insulation. Pipe and boiler insulation was often covered by painted canvas or sheet metal.

A more durable product was created by using cement, vinyl, or asphalt as a binder. This non-friable asbestos cement was used in pipe form for sewers and water supply. Roofing, siding, and firewall construction were sheet-form applications. Valve and elbows may be covered by site-mixed asbestos cement. Acoustical plaster was also usually mixed at the site and applied on school, hospital, and commercial building walls. Vinyl and asbestos were formed together into flooring as sheets and tiles. Other, more varied uses of non-friable material include: drywall joint-filling compound, coatings and mastics (filler for cements and caulkings), and gaskets and packings.

The asbestos "dust" from friable material, or from cutting or breaking asbestos cement, causes most health concerns. Applications of white asbestos are no longer allowed in most countries, due to the risk to workers during installation and removal. The diseases that may result due to exposure to asbestos include impairment of respiratory function leading to heart failure, lung cancer, and malignant tumour growth in the chest.

In 1988, Canada adopted the International Labour Organization (ILO) Convention 162 'Safety in the Use of Asbestos,' which takes a 'controlled use' regulatory approach. That is, some types of asbestos use persist, however, products containing crocidolite, and sprayed on applications are prohibited. Continued use of chrysotile in applications like asbestos cement may be permissible, but exposure limits have been imposed.

The ILO Convention outlined a hierarchy of preventative and control measures which prescribe:

- adequate engineering controls and practices
- special rules and procedures for the use of asbestos of certain types, or for certain work processes
- where necessary for workers' health and technically feasible, replacement of certain types of asbestos by scientifically evaluated materials that are less harmful
- a total or partial prohibition of the use of asbestos of certain types or for certain processes.

Provincially, Ontario Regulation 838, RRO 1990 (as amended) 'Regulation Respecting Asbestos on Construction Projects and in Buildings and Repair Operations,' made under the Occupational Health and Safety Act, governs the removal and handling of this material. Thus, a professional survey for asbestos-containing material in any older building is warranted.

Above all, an asbestos program must ensure the health of maintenance workers and building occupants. To this end,

- All friable material should be identified and its location recorded.
- An asbestos inspection should note the condition of the material, in order to determine the necessity of repair to any damaged areas, or other remedial action.
- Access to areas containing asbestos should be controlled.
- Workers who may disturb friable asbestos-containing material should be trained and educated.

In the Ontario Regulation 838, RRO 1990 (as amended), all asbestos-related work has been classified according to type (I, II, and III). The appropriate procedures for such work should be noted according to type, and records maintained. Upon awarding any construction contract, a building asbestos report should be provided to the contractors, and their work should be monitored. Compliance with the Worker's Compensation Board and local health authorities standards is necessary.

In addition to asbestos, there are other mineral fibre issues that should be raised. Wollanstonite, and attapulgite are naturally occurring fibres, while glass, rock, and slag wool are manufactured. Some of these fibres have been included on lists of known carcinogenic substances, or lists of probable cancer-causing agents.

Recommendations for the consideration of building managers include:

- Fibrous duct liners should be completely avoided in all ventilation ducts or equipment (fan chambers) except sound attenuators of up to 4m in length in return air paths.
- Fibrous duct liners covered with durable polymer or foil-coating materials should be confined to ventilation ducts or equipment in return air paths.
- A check as to the soundness of supply air ducts with fibrous liners coated with durable polymer or foil coating should be made.

Source: Ontario BEPAC Manual

Recent research confirms that ceramic fibres are cancer-causing. It may be advisable to control exposure to these fibres, following the methods of asbestos management.

Ozone-Depleting Substances

Canadian regulations require the phase-out and eventual elimination of ozone-depleting substances (ODSs). For building managers, the substances of particular concern are refrigerants (mainly CFCs) and fire suppressants (halons). The list below gives the ozone-depleting, and global-warming potentials of both types of substances. The development of a plan to meet both present regulatory requirements and the longer term national goal of ODS elimination is a necessity.

Refrigerant/ Halon	Typical Use	Ozone-depleting Potential	Global-warming Potential
CFC-11	Chiller Refrigerant	1.00	1.00
CFC-12	Refrigerant	1.00	3.20
CFC-502	Refrigeration	0.23	
HCFC-22	Chiller Refrigerant	0.05	0.34
HCFC-123	Chiller Refrigerant	0.0175	0.02
HFC 134a	Chiller Refrigerant	0.00	0.305
Halon-1211	Fire Suppressant	3	
Halon-1301	Fire Suppressant	10	

Source: Ontario BEPAC Manual

CFCs, or chlorofluorocarbons, were thought to be ideal refrigerants for air conditioning and refrigeration systems when they first became widely available for commercial use, in the 1930s. However, CFCs and HCFCs (hydro chlorofluorocarbons), when exposed to the atmosphere, have the effect of destroying the protective ozone layer, which filters harmful ultraviolet (UV) radiation. In turn, plant, animal, and human health suffer.

The Montreal Protocol was an international agreement to protect the ozone layer that became effective January 1, 1989. At that time, 29 countries and the EEC ratified the agreement. Now, 155 countries are Parties to the Convention for the Protection of the Ozone Layer, and the Protocol. On June 2, 1994, the federal government's ODS regulations came into force.

Under these regulations, elimination virgin CFC consumption (production + import - export) at the national level should have occurred by January 1, 1996. The regulations control import, manufacture, use, sale, and export of ozone-depleting substances. The HCFC phase-out goal is January 1, 2020. (Other regulations, Ozone-Depleting Substances Products Regulations -amended June 2, 1994 - prohibit the manufacture, import, sale, and offer for sale of certain products containing ODSs.)

As a companion aid to these laws, Environment Canada offers non-regulatory programs to assist in the phase-out of ODSs. These programs consist of a Code of Practice for the Reduction of CFC Emissions from Refrigeration and Air Conditioning Systems, an Ozone-Depleting Substances Alternatives and Suppliers List, and the ODS Pollution Prevention Management Plan. As well, provincial programs control the end uses of ODSs, encourage ODS recovery, recycling, and emission reduction.

Of primary concern to building managers is the phase-out of chiller refrigerants R-11 and R-12 which began in January 1, 1996 (along with that of other CFCs). Although continued usage in existing equipment is permitted, many options exist to reduce present CFC emissions. Management should make a commitment and develop a plan to reduce ODSs, including generating a target year for elimination, and a schedule for retrofit or replacement of equipment. To begin, consider factors such as chiller age, condition, type, amount of refrigerant required, equipment usage, and budget. Ontario Hydro recommends a three-step process that begins with selecting a qualified team for refrigerant management. A complete inventory of refrigerants and CFC-using equipment is complemented by records of refrigerant leakage rates. A management plan ensures leaks are properly repaired.

In existing chillers, near zero emissions can be achieved by keeping equipment in good working condition, employing containment practices, and implementing refrigerant recovery, reclamation, and recycling. The Ontario BEPAC recommendation for the first step, maintaining good working condition of the chiller, is to ensure equipment does not vent improperly. Refrigeration systems should be furnished with high efficiency purge processes (discharging less than two parts refrigerant per one part air by mass), and with run-time indicators or purge flow meters. Recovery, reclamation, and recycling follow from responsible use of the current refrigerant.

Conversion to a non-CFC refrigerant is an option. A compatibility conversion is the simplest, since only the refrigerant and necessary components for maintaining operation are replaced. Almost inevitably, a loss in efficiency and cooling capacity results. An engineered conversion trims or replaces impellers to maintain capacity, and may include a drive line changeover, which is more involved. Motor, compressor, gears, and impellers are replaced, maintaining or improving efficiency, but this is obviously a costly step.

Some alternative refrigerants contain a blend of HCFCs and HFCs. The ozone-depleting potential of these blends is much lower than that of traditional refrigerants, although HCFCs are only transitional substances, use of which must be ended in 2020, as noted above. The desirability of a conversion measure should be given some consideration, since more environmentally safe technologies exist, but all factors for specific situations should be weighed. Ontario Hydro's estimate of the cost of conversion is 20-90% of the cost of a new chiller.

If building loads have changed, surplus equipment may be disposed of, reducing, or in some cases perhaps eliminating the amount of old refrigerant required. Retaining any of the old refrigerant will eventually become a drawback, as supply dwindles and gradually becomes more expensive. While leak detection and repair, preventative maintenance, installation of devices to capture emissions or monitor operation, and reusing, recovering, and recycling refrigerant can significantly reduce consumption, these are short term solutions. The time gained can be used for assessing the best option for the next stage.

If not converted to alternative substances, equipment must be replaced. When this time comes, the first course of action should be to reduce cooling loads to decrease both the size of the new system, and of course, its cost. Improved ventilation systems, better insulation, window films and coatings, ceiling fans, shades, and awnings are all viable methods to reduce the cooling load on an air conditioning system. Lighting measures are of primary importance. Ontario Hydro estimates that every kWh of energy saved through lighting measures will save approximately 0.5 kWh to drive the chiller, fans, and pumps. Delamping as well as retrofitting can pay back in about three years.

A host of issues must be addressed when a new system is chosen:

- regulatory compliance
- ozone-depleting potential
- global-warming potential
- energy efficiency
- toxicity
- flammability
- performance
- need for replacement of lubricants or hardware
- cost-efficiency of the option.
- an implementation schedule should be developed, with a target for end of ODS use
- a designated manager should be responsible for implementation of and commitment to zero ODS use.

Ultimately, the aim is to eliminate all environmentally harmful effects of building refrigeration and fire suppressant systems.

PCB Waste

A PCB is any monochlorinated or polychlorinated biphenyl (fused benzene ring with bonded chlorine atoms) or any mixture that contains one or more of them. PCB compounds are stable at high temperatures, and somewhat soluble in water. In the 1970s, PCBs were identified as a suspected human health hazard. Although there has been some evidence that, except in high concentrations, the health risks are low, PCBs are bioaccumulative, and have been found to cause reduced litter sizes and birth defects in animal offspring. PCBs have been found in animals in remote regions, and in human fatty tissue and blood. The greatest risk from PCBs lies in their conversion, at very high temperatures, into dioxins and furans, some of the deadliest, most carcinogenic substances known.

In a recent study, comparing two groups of people, only one of which was exposed to PCBs in a recent fire, it was found that every person tested, even in the control group, had measurable levels of dioxins and furans in their bodies. Beluga whales in the St Lawrence contain PCB levels of 600 ppm whereas EPA standards give levels of more than 50 ppm as a hazardous waste site. Thus, the present concern of building managers should not only be storage and handling and the immediate danger to building personnel, but the ultimate environmental fate of these toxins.

Historically, the major source of PCB material in buildings has been in equipment that has been removed from service or decommissioned. In 1977, under the Canadian Environmental Contaminants Act, Canada banned the use of PCB additives in lubricants, heat transfer fluids, and adhesives, but hydraulic equipment, oil-filled electromagnets, circuit breakers, voltage regulators, cables and vacuum pumps manufactured prior to 1980 may contain PCBs.

Almost every capacitor manufactured between 1930 and 1980 contains PCB dielectric liquid. Small capacitors are used in fluorescent light ballasts, and other electronic equipment. Large capacitors contain more than 0.5 kg of PCBs. In buildings, capacitors can be found connected to larger AC motors wired to electric terminals. Often they are recognizable by the KVAR label (5 KVAR to 200 KVAR) stamped on them, and unless clearly date marked, can be assumed to be PCB contaminated.

The primary provincial legislation affecting PCBs is Regulation 362, *'Waste Management – PCB Regulation.'* Federally, the important documents are: Chlorobiphenyls Regulations (SOR/91-152) and *Storage of PCB Material Regulations* (SOR/92-507), both of which are issued under the Canadian Environmental Protection Act. There are some differences in the regulations, as each highlights a certain area (management versus storage), however, provincial legislation takes precedence when it exists.

The Ontario Regulation differentiates between PCB waste, liquid, and equipment.

PCB material is any substance that contains more than 50 ppm by weight, whether or not the substance is liquid. A PCB liquid contains a concentration of 50 ppm or more by weight, unless the liquid is used for road oiling. In this case a PCB liquid contains 5 ppm or more by weight. Any liquid made by diluting either of these two types of liquids is a PCB liquid.

PCB equipment is equipment designed to operate with PCB liquid, or to which PCB liquid has been added. Equipment includes drums or containers that store PCBs.

Collectively, these definitions are used to define PCB waste, a designation that is more complicated, and to which there are exceptions. The Chlorobiphenyls Regulations (SOR/91-152) record the various cases for which the use, sale, and importation of PCBs in excess of 50 ppm is prohibited. PCB equipment in service does not need to be registered with the Ministry of Energy and Environment (MOEE), however, labelling this equipment will assist in inventory control, storage, handling, and eventual disposal. Both the MOEE and Environment Canada maintain records of labelled equipment, and should be informed of equipment status (e.g. out of service, relocated. stored, decontaminated, disposed of).

Unless verified as PCB-free by an accredited lab, equipment should be treated as suspect. PCB equipment must be carefully decommissioned. The MOEE must be notified, and site, and material must be registered. Special procedures and safety precautions must be in place for anyone planning on handling PCB equipment. Currently, disposal of PCB wastes is limited by the number of facilities that are approved for handling this material. Export of such waste is prohibited.

Also, categories of high-level and low-level wastes exist, and these types can be managed differently. High-level waste destruction is limited to the Swan Hills site, operated by Chem-Security, in Alberta. Decontamination of parts may be done at other places, such as the autoclave decontamination centre, Les Recyclages Larouche inc, north of Quebec City. Low-level wastes may be treated on site using a chemical destruction process. Companies like ELI Eco Logic travel to the site with a process reactor that is capable of reducing PCBs and dioxins to methane and hydrogen chloride (HCl). There are many companies that offer PCB disposal services, but most are brokers for Chem-Security of Alberta. It is recommended that building owners and managers use the services of a qualified and certified hazardous waste management company when considering disposal of PCBs.

Section 4 of Regulation 362 outlines the responsibilities that a 'site' operator has with respect to record keeping and reporting to the MOEE. Section 5 requires that certain activities such as removing and transferring PCB waste can only be done under the supervision of an MOEE director. Section 7 requires that every person storing PCB waste shall ensure that the waste is in a safe and secure location so as to prevent any contact with people or a watercourse or ground water. Proper storage is defined in CEPA Regulation 92-507.

The issues addressed consider site security and access, type of containers, precautions against leaks to the environment, container stacking, fire protection and emergency procedures, maintenance, and inspection practices. Special labels have been devised to identify drums, tanks, packaging containing contaminated mineral oils, rinsing fluids, or other containers for low-level PCB waste. Environment Canada recommends that the owner of PCB wastes retain an inventory record for five years after removal or disposal of the last of the PCBs.

Ontario Regulation 347 requires that the owner of a site where PCB wastes are stored must be registered as a hazardous waste generator and must meet various requirements for safety, storage of waste, and record keeping.

Again, for transportation, special rules have been laid out, which involve labelling, safety marking and documentation. Federally, the shipment of PCBs is governed by the Transportation of Dangerous Goods Act (TDGA). Leak-proof containers and packaging suitable for PCBs are required, and road carriers must be inspected every two hours or every 200 km, whichever comes first.

Essentially, the regulations regarding PCB handling are extensive and subject to change. It is recommended that building owners and managers seek the services of a consultant specializing in PCBs when any issues arise.

Fluorescent and HID Lamp Recycling

Fluorescent and high-intensity discharge (HID) lamp disposal is an on-going concern. HID lamps include mercury vapour, high-pressure sodium, low pressure sodium, and metal halide. Energy-saving retrofit measures or group relamping may result in hundreds of redundant lamps at a site. Over the life of a building, the volume of this hazardous waste disposal becomes significant. Asbestos, PCBs, and ozone-depleting substances can be eliminated, but as yet, mercury in fluorescent and HID lamps cannot. Manufacturers are reducing the amounts of heavy metals in lamps, but these harmful substances will continue to be an issue.

The toxic affects of mercury vary depending on the amount of exposure and the length of time a worker is exposed. Acute, or 'short-term' effects are those resulting from one large exposure. Chronic, or 'long-term' effects occur with frequent exposure to small doses over long periods of time. Mercury vapour can be absorbed through the skin, and can be ingested (in water or food). Acute effects result when metallic mercury vaporizes into the air at standard temperature and pressure. The result is shortness of breath, tightness of the chest, cough, fever and sweating. Chronic effects are due to a build up of mercury in the kidney or the brain. Tremors in the hand are the first sign, spreading to the arms and legs through continued exposure. Behavioural effects are shyness, sleeplessness, irritability, depression and moodiness. Facial pallor, swelling of the mouth and gums, and severe stomach pains can occur. Birth defects have been related to exposure to mercury of pregnant women.

Federal and provincial hazardous waste disposal regulations require that companies disposing of fluorescent and HID lamps test the waste using a standard leachate test for mercury. Under Ontario Regulation 347, a test exceeding 0.01 mg/kg means that a company with such lamp waste must handle it as a hazardous waste, i.e., the material is forbidden from ordinary landfill. Research by lighting companies and regulatory agencies has shown that, almost without exception, fluorescent and HID lamps will exceed the leachate toxicity threshold.

There are different options for disposing of lamp waste, and as always, considerations include current regulatory requirements, liability, cost, and environmental responsibility.

As noted above, disposal of lamps in regular landfill is contrary to current waste regulations, and environmentally irresponsible. The option of disposal in a hazardous waste landfill site also exists. Crushed lamps are packed into drums and hauled away. Several concerns about this 'crusher' method were raised a few years ago in the United States, where more than half a billion mercury-containing lamps are produced each year. If not managed properly, the crushing operation can cause leaks of mercury vapour to operator areas.

As well, improper or insufficient heavy metal removal may mean that mercury is added to the landfill site. Addition of mercury to landfill sites has led to contamination of fish populations throughout the US Since this time, awareness of these concerns has increased, and technology has improved.

Raylex in Burlington, Ontario crushes lamps, abstracts heavy metals in solid and vapour form, cleans the lamps, and sends them to a landfill. Mercury and other heavy metals are shipped to another processor for recycling. Other recycling programs may recapture almost one hundred percent of lamp material, and all of the contaminants. Fluorescent Lamp Recyclers in Cambridge, Ontario recycle glass, aluminum, and brass, as well as mercury and phosphor. Contacting one of these businesses, or your local municipality's waste reduction department may provide a starting point for an 'in-house' program.

Fatal Light Awareness Program (FLAP)

Many of Canada's 250 species of migratory birds are in decline. Habitat destruction and pollution threaten them on their breeding grounds in Canada and on their wintering grounds in the U.S. and Latin America. In addition to these threats, millions of birds die or suffer injuries from collisions with buildings lit at night as they journey north and south.

Birds migrating night are strongly attracted to, or at least trapped by, sources of artificial light, particularly during periods of inclement weather. Approaching the lights of tall buildings, they become vulnerable to collisions with the structures themselves. Even if collision is avoided, once inside a beam of light, birds are reluctant to fly out of the lighted area into the dark, and often continue to flap around in the beam of light until they drop to the ground with exhaustion. Further, migrating birds trapped in an urban environment may have difficulty in finding food.

The simplest solution is to turn out the lights, particularly after midnight when birds begin to descend from their peak migration altitudes. Structural possibilities include the use of shielding to direct light downward and thus prevent its visibility from above, installing blinds or shutters on the windows which can be closed at night, and installing perches on the sides of the building to provide a resting place. Bird attractants such as bird feeders and baths can be placed within one metre or beyond ten metres from windows in order to reduce collision mortality.

Further research is required to determine insight into various components of the problem, including the effects of building height, lighting types, light shielding, and the effects of other deterrents.

6. Useful Information

6.1 Regulations

There are several regulations which impact on energy and water use and waste management in office buildings. For energy and water, some of these only affect the construction of new buildings, while others are integrated into the manufacture and distribution of equipment which may be purchased for replacement. The criteria for new buildings, however, represent reasonable guidelines for an existing building when they can be applied, particularly where a renovation is undertaken. Waste management regulations affect the ongoing operation of the building.

Energy

New Building Design

The Ontario Building Code requires that all new buildings be designed to be energy efficient in accordance with ASHRAE/IES Standard 90.1-1989, "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings," and the companion volume, "Guidelines for the Interpretation of ASHRAE/IES 90.1-1989," published by the Ministry of Municipal Affairs and Housing.

The standard sets forth criteria for energy efficiency in the following areas:

- *Electric Power*: Minimum motor efficiencies, steps to allow metering of power consumption, examination of transformer losses
- *Lighting*: Maximum allowable power for exterior and interior lighting, requirements for controls, minimum ballast efficiencies
- *Other Systems & Equipment:* Recommendations for freeze protection, elevators and escalators, and refrigeration efficiencies
- *Building Envelope:* Minimum performance standards for windows, insulation levels for walls, roof and foundation
- *Heating, Ventilation and Air Conditioning Systems and Equipment:* Minimum equipment efficiencies, controls for energy conservation, energy efficient system design
- *Service Water Heating:* Minimum equipment efficiencies, controls for energy conservation, efficient system design, requirements for swimming pools

Ventilation

ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality" is cited in the Ontario Building Code as good engineering practice, and is widely accepted as the reference on this subject.

Recommended ventilation levels are:

- *Office space:* 20 cfm/person (10 L/s/person)
  (cubic feet per minute per person)
- *Reception areas:* 15 cfm/person (8 L/s/person)
  (plus supplementary smoke removal)
- *Conference rooms:* 20 cfm/person (10 L/s/person)
  (plus supplementary smoke removal)

Space Heating/Cooling

The efficiency of all space heating and cooling equipment is determined by test standards developed and published by the Canadian Standards Association (CSA), and by the American Refrigeration Institute (ARI). The efficiency of gas and oil-fired hot water boilers and furnaces is determined by test standards developed and published by the Canadian Gas Association (CGA), and by the Gas Appliance Manufacturers Association (GAMA). Minimum efficiency levels for this equipment sold in Ontario are regulated under the Ontario Energy Efficiency Act by the Ministry of the Environment and Energy.

Service Water Heating

The efficiency of service water heaters is determined by test standards developed and published by Canadian Standards Association (CSA) for electric heaters, and by the Canadian Gas Association (CGA) and the Gas Appliance Manufacturers Association (GAMA) for gas-fired heaters. Minimum efficiency levels for this equipment sold in Ontario are regulated under the Ontario Energy Efficiency Act by the Ministry of the Environment and Energy.

Other Equipment

There are no mandated minimum efficiency standards for office equipment in Canada. In the USA, the Department of Energy (DOE) promotes a program called "Energy Star" for energy efficient office equipment which generally requires that some types of office equipment go into a "sleep" mode when not called upon within a prescribed period of time, but which can warm up quickly when necessary. Products meeting this standard are widely distributed in Ontario.

Water

For new buildings, the current Ontario Building Code mandates the use of water conserving faucets, shower heads, and flush toilets.

Specified maximum allowable usage levels are:

• Lavatory faucets	8.35 L/min
• Kitchen faucets	8.35 L/min
• Shower heads	9.50 L/min
• Water closet (tank type)	6.0 L/flush cycle
• Water closet (direct flush)	6.0 L/flush cycle

Most products currently offered for sale in Ontario meet these requirements.

Waste

Of all the provinces and territories, only Ontario has formally implemented legislation mandating waste audits. In March 1994, the 3R's Regulations were passed into law, requiring targeted industrial, commercial and institutional (IC&I) sectors to conduct a waste audit and prepare a waste reduction work plan. These targeted sectors, including office buildings with a floor area greater than 10,000 m^2, were to have undertaken a waste audit and completed a waste reduction work plan by September 1994. The work plan must be implemented by March 1995.

Materials targeted for source separation and recycling in office buildings include:

- corrugated paper
- fine paper (office paper)
- newspaper
- food and beverage containers made of aluminum, glass or steel.

A company may choose to combine recyclable waste and have it separated by a recycling company.

In order to remain in compliance, the audits and work plans must be updated on an annual basis and maintained on file for five years. The audit results are not required to be submitted to the Ministry of Environment and Energy (MOEE) but it is up to the discretion of the MOEE to ask for copies of the work plan from targeted companies. The legislation is currently under review by the government of Ontario.

The municipality in which the office building is located may impose landfill bans on designated materials that are considered easy to recycle, such as cardboard, wood waste and construction waste. The municipal recycling coordinator and waste hauler will know which materials are banned and should be willing to work with office building staff to ensure that these materials stay out of the dumpster. It is not uncommon for municipal staff to reject loads of waste or to double the tipping fee. These costs will be passed on to the generator by the hauler.

Environmental Regulations

Federal

Canadian Environmental Protection Act, R.S.C. 1985, c. 16 (4th Supp.); amended by 1996, c. 8.
- Export and Import of Hazardous Wastes Regulations, SOR/92-637
- Federal Mobile PCB Treatment and Destruction Regulations, SOR/90-5
- List of Hazardous Waste Authorities, SOR/92-636
- PCB Waste Export Regulations, SOR/90-453
- Chlorobiphenyls Regulations, SOR/91-152

Provincial

Environmental Protection Act, R.S.O. 1990, c. E-19
- General - Waste Management Regulation, R.R.O. 1990, Reg. 347
- Halon Fire Extinguishing Equipment, O. Reg. 413/94
- Mobile PCB Destructions Facilities Regulation, R.R.O. 1990, Reg 352
- Ozone-Depleting Substances - General Regulation, R.R.O. 1990, Reg. 356
- Waste Audits and Waste Reduction Work Plans Regulation, O. Reg. 102/94
- Waste Management - PCBs Regulation, R.R.O. 1990, Reg. 362

Occupational Health and Safety Act, R.S.O. 1990, c. O-1; amended by 1995, c. 5
- Designated Substance - Asbestos, R.R.O. 1990, Reg. 837
- Designated Substance - Asbestos on Construction Projects and in Buildings and Repair Operations, R.R.O. 1990, Reg. 838
- Designated Substance - Mercury, R.R.O. 1990, Reg. 844
- Hazardous Materials Inventories Regulation, R.R.O. 1990, Reg. 850
- Workplace Hazardous Materials Information System Regulation, R.R.O. 1990, Reg. 860

Ozone-Depleting Substances

- Environment Canada, *Code of Practice for the Reduction of CFC Emissions from Refrigeration and Air Conditioning Systems*, 1991.
- Environment Canada, *ODS Bulletin,* 1995-96.
- Environment Canada, *ODS Pollution Prevention Management Plan,* 1995.
- Environment Canada, *Ozone-depleting Substances Alternatives and Suppliers List,* 1994.
- Building Owners and Managers Association (BOMA), *The Refrigerant Manual: Managing the Phase-Out of CFCs,* 1993, 136 pp.

Hazardous Substance Disposal

Asbestos

Zerofibre	130 Conrad Crescent Unit 12 Markham, ON L3R 0G5	905-470-7424
Envirosafe Inc	80 Nashdene Rd Unit 51 Building B Scarborough, ON M1V 5V4	412-292-1373

PCBs

ConTech	7-125 Turnbull Crt Cambridge, ON N1T 1H8	519-622-8058
ELI Eco Logic International	143 Dennis St Rockwood, ON N0B 2K0	519-368-8429
Resource Environmental Ass.	330 Bay St 6th Floor Toronto, ON M5H 2S8	416-368-8429
Chem Security (Bovar Inc.)	2 Tippett Rd 2nd Floor Toronto, ON M3H 2V2	416-630-8322

Fluorescent Lamps

Fluorescent Lamp Recyclers	110 Turnbull Court Unit 15 Cambridge, ON N1T 1K6	519-651-2606
Raylex	5450 Harvester Rd Burlington, ON L7L 5N5	905-681-7110
Green-Port (also PCBs)	16 Melanie Dr. Brampton, ON L6T 4K9	905-799-2777

6.2 References

Advanced Buildings Newsletter, Royal Architectural Institute of Canada: 55 Murray St., Ste. 330, Ottawa ON K1N 5M3

"Establishing Priorities with Green Buildings" by Alex Wilson and Nadav Malin outlines a priority list of eleven measures including water efficiency, materials selection, IAQ control, construction practices and environmental awareness programs for building occupants. March 1996

American Council for an Energy Efficient Economy (ACEEE): 1001 Connecticut Ave., NW Ste 801, Washington DC 20036, Research and Conferences (202) 429-8873, Web: www.aceee.org

Publishes books and articles on energy efficiency in buildings and components. All publications are available on the worldwide web, and can be ordered through the Internet site www.crest.org\aceee.

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): 1791 Tullie Circle, N.E., Atlanta GA 30329

ASHRAE/IES Standard 90.1-1989, "Energy Efficient Design of New Buildings, Except Low-Rise Residential Buildings"
ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality"
ASHRAE Standard 100.3-1991, "Energy Conservation in Existing Buildings - Commercial Buildings"

BEPAC Foundation: 1663 Book Rd. W.,Jerseyville, ON L0R 1R0, (905) 648-0536

Building Environmental Performance Assessment Criteria for office buildings in Ontario

Canadian Standards Association (CSA): 178 Rexdale Blvd., Etobicoke ON M9W 1R3, (416) 747-4000, Web: www.csa.ca

CSA Standard Plus 1132, "BREAM - CANADA: An environmental performance assessment for existing office buildings"
CSA Standard Plus 1140, "A Voluntary Energy Management Guideline"

Energy Efficiency and Renewable Energy Clearing House (USA): P.O. Box 3048, Merrifield VA 22116, 1-800-DOE-EREC, Web: www.eren.doe.gor/erec

Offers publications on energy conservation in commercial buildings.

Energy Technology Data Exchange (ETDE): Member Country Contact - Mr. Mac Nason, Manager, CANMET Information Centre, NEC, 555 Booth St., Ottawa ON K1A 0G1, Tel: (613) 992-8837 Fax: (613) 995-8730, Web: www.etde.org

The ETDE is one of the largest worldwide energy databases available, offering all forms of energy literature. The web site for ETDE gives only information on participating organizations. To access the database, one must either pay fees to become a member or pay a one time fee and have a reference librarian do a search.

Environmental Choice Program: TerraChoice Environmental Services Inc., Ottawa ON, Tel: (613)247-1900, Web: http://terrachoice.ca/ecologo.htm

Green Procurement Institute (formally Buy Canadian Recycled Alliance): Ottawa ON, Buy Green - The Green Procurement Home Page, Tel: (613) 237-4588, Web: http://www.buygreen.com, Greening Government - Green Procurement, Web: http://www.doe.ca/gog/procure/index.htm

Guide to Environmental Purchasing: Toronto ON, Tel: (416) 392-7313
Governments Incorporating Procurement Policies to Eliminate Refuse (GIPPER). March 1995. GIPPER's Guide to Environmental Purchasing (Second Edition).

International Energy Agency (IEA): 9 re de la Federation, 75739 Paris Cedex 15, France, Tel: 33-1-40 57 65 54 Fax: 33-1-40 57 65 59, Web: www.ica.org
The IEA has established an Implementing agreement on Energy Conservation in Buildings and Community Systems (ECBS), aimed at initiating research and providing an international focus for building energy efficiency. Results of the research are used nationally and internationally to develop standards and guidelines. Research is being done in the areas of energy management systems and controls, development and evaluation of design tools, energy retrofitting, ventilation and indoor air quality, community planning, advanced building materials and advanced systems.

National Research Council of Canada (NRC): Montreal Rd., Ottawa ON, Web: www.nrc.ca
"National Model Energy Code for Buildings, 1996." Model energy code for new building design

Natural Resources Canada: NRC Headquarters, St. William Logan Bldg., 580 Booth St., Ottawa ON K1A 0E9, (613) 995-0947
National Energy End-Use Database - information on energy efficient products and systems.

Ontario Hydro: 700 University Ave., Toronto ON M5G 1K6, Web: www.hydro.on.ca
"Commercial Energy Management Fundamentals," details types of energy efficient systems and their operation: heat pumps, hot water heating, heating, insulation and cooling.

Ontario Ministry of Environment and Energy: Industry Conservation Branch, 2 St. Clair Ave. W., Toronto ON M4V 1L5 (416) 327-1484
"Guide to Resource Conservation and Cost Saving Opportunities in the Food Service Sector," provides guidance to conserving energy and water, and reducing waste in food service operations.

Ontario Realty Corporation, The Green Workplace: 777 Bay St., 15th Floor, Toronto ON M5G 2E5
Offers a comprehensive program on waste management for offices buildings entitled "Maximum Green," also "How the Ontario Public Service Handles its Greening".

Ontario Waste Management Association: 4195 Dundas St. W., Toronto ON M8X 1Y4 Tel: (416) 236-0172 Web: www.owma.org
Represents waste hauling industry. Offers training and education programs for this industry.

Recycling Council of Ontario: 489 College St., Toronto ON M6G 1A5 Tel: (416) 960-1025 Web: www.web.net/rco
Offers educational and information programs on reducing, recycling and reusing waste

US Environmental Protection Agency Green Lights Program: US EPA, Atmospheric Pollution Prevention Division, 401 M Street SW (62 02J), Washington DC 20460, Tel: (202) 233-9190, toll free: 888-star-yes, Fax: (202) 233-9569, Web: www.epa.gor/greenlights.html
This program describes energy efficient measures for implementation in retrofit projects in commercial buildings.

US Environmental Protection Agency Energy Star Program: US EPA, Atmospheric Pollution Prevention Division, 401 M Street SW (62 02J), Washington DC 20460, Tel: (202) 233-9190, toll free: 888-star-yes, Fax: (202) 233-9569, Web: www.epa.gor/energystar.html
This program establishes standards for energy efficient office equipment.

6.3 Training

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
1791 Tullie Circle NE, Atlanta GA 30329-2305 1 800 527-4723 Web: www.ashrae.org

Courses offered on all aspects of heating, ventilating, air conditioning and controls as individual study or classroom study.

BOMI Canada: 885 Don Mills Rd., Ste 106, Don Mills ON M3C 1V9 (416) 443-8790
Web: www.bomi-edu.org

Courses offered in commercial property as individual study or leading to a professional designation. Courses offered as self-study, classroom study, accelerated review, facilitated group study, and corporate classes. Classroom study offered by BOMA chapters in Toronto and Ottawa.

Real Estate Institute of Canada: 5407 Eglinton Ave. W., Toronto ON M9C 5K6 1 800 542-7342
Web: www.reic.ca

Courses offered in all aspects of real property management.

Seneca College: Energy Training Ontario, 16775 Yonge Street #217, Newmarket ON L3Y 8J4
Tel: (905) 727-0712 Web: www.senecac.on.ca

A full range of building operations and management subjects through Seneca's Building Environmental Systems program (BES) is available in classroom format through a network of Ontario colleges in association with the Ministry of Environment and Energy or by individualized distance learning through Seneca College.